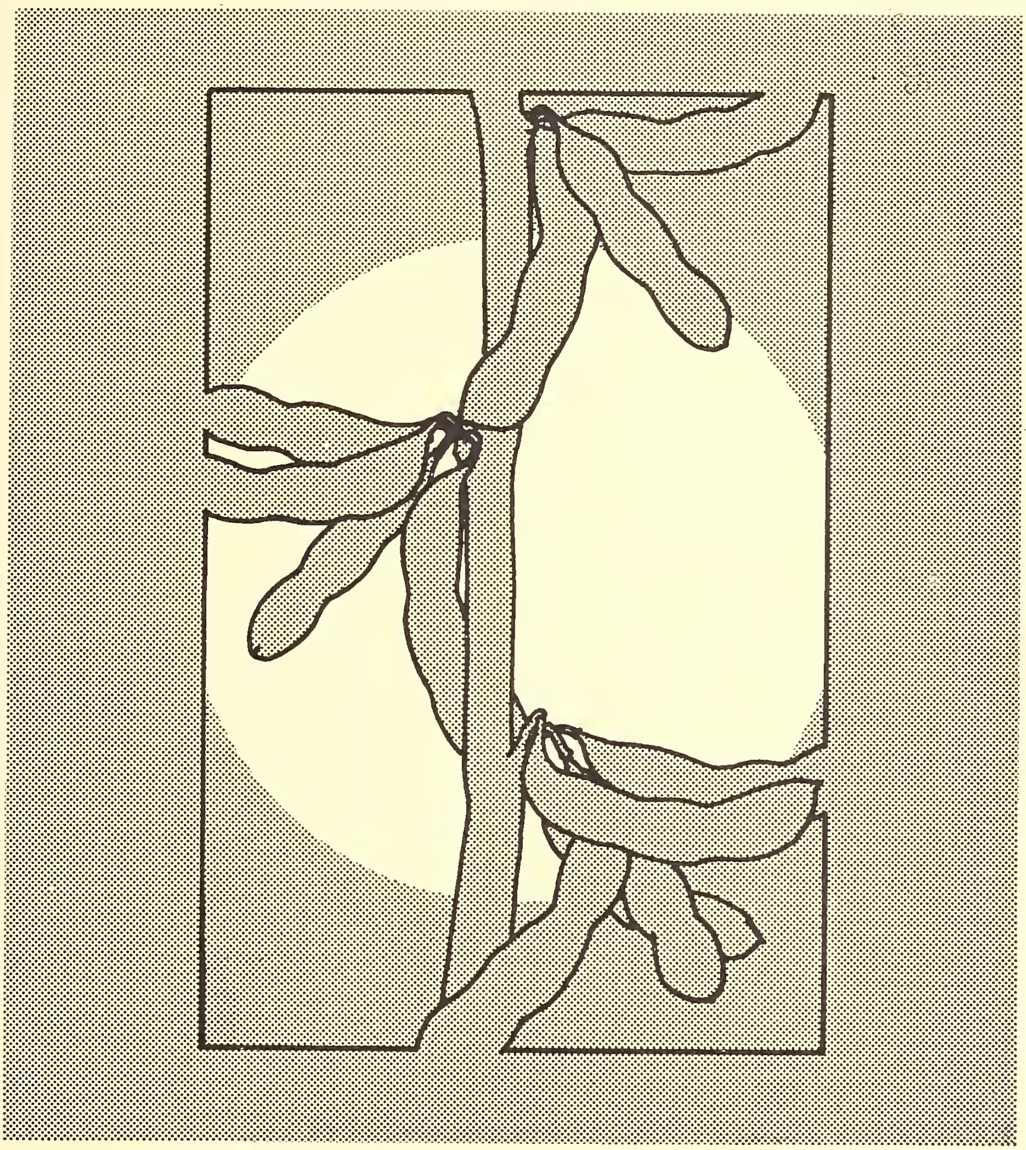
Soybean Genetics Newsletter



Volume 3 April 1976

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Agricultural Research Service - USDA
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I. FOREWORD

We are gratified by the enthusiastic response of our contributors to Volume 3 of the Soybean Genetics Newsletter. Our printing order for this volume is 600; the mailing list covers 48 countries and 34 states.

The variety, scope and excellence of the articles in this volume indicate a growing acceptance of the Newsletter as a medium for the exchange of ideas and information among soybean scientists around the world. Suggestions for improvement of the SGN are requested and appreciated.

The details of producing the SGN involve our whole staff--technicians, secretaries and graduate students. Those "volunteered" for duty this year include Hollys E. Heer, Carol Winger, Linda Martin, Marc Albertsen and David Stelly.

ACKNOWLEDGEMENT

We wish to express our appreciation to the Iowa-Missouri area director of the USDA-ARS for the financial support which made this issue of the Soybean Genetics Newsletter possible.

Reid G. Palmer

II. ANNOUNCEMENTS

1. Compendium of Soybean Diseases

Edited by J. B. Sinclair and M. C. Shurtleff, University of Illinois, Urbana-Champaign, Illinois. Price US $6.00 per copy and can be ordered from the American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, MN 55121, USA.

2. An Annotated Bibliography of Soybean Diseases

By J. B. Sinclair and O. D. Dhingra, University of Illinois, Urbana-Champaign, Illinois. The Bibliography lists over 2000 citations dating from 1882. Authors' original abstracts have been used whenever possible. The size and cost of this publication require that US $12.00 per copy be charged. The Bibliography can be ordered from INTSOY, 113 Mumford Hall, University of Illinois, Urbana, IL 61801, USA.

III. REPORT OF SOYBEAN GENETICS COMMITTEE

A) The current members of this committee and the expiration dates of their terms are:

R. L. Bernard, Chm. (1978)
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B) Organization of the Committee:

1) The Committee will be composed of six elected members and the editor of the Soybean Genetics Newsletter.

2) The term of the elected members will be three years. After a member has been off for one year, he (she) can be reelected. The Committee will elect two new members each year; a simple majority is needed for election. The members will be elected prior to February 1 of each year, by a mail ballot conducted by the chairman.

3) At the annual meeting of the Committee (usually in February in conjunction with the Soybean Breeding and Genetics Workshop), the two new members and the two retiring members of the Committee are eligible to attend and vote.

4) The Chairman will be elected at the annual Committee meeting and serve through the next annual meeting, and may be reelected.

C) The duties of this Committee were reviewed and revised at Memphis, TN, February 23, 1976, and the following procedures were established:

1) Maintain Genetic Collection.

The Genetic Collection is divided into four categories:

a) Type Collection includes all published genes of soybeans, preferably in the original strains (excluding U.S. and Canadian name varieties, which are maintained in a separate collection) plus certain mutants or strains that appear to the Committee to have potential genetic interest.

b) Isoline Collection includes adapted varieties Clark, Harosoy and Lee, into which have been backcrossed single genes or combinations of genes. Also included are certain genes or combinations with Chippewa, Wayne and Williams.

c) Linkage Collection includes linkage combinations and the various genetic recombinations.

d) Cytological Collection includes translocations, inversions, deficiencies, trisomics, tetraploids, etc.

Collections a, b and c are maintained at Urbana, Illinois, with R. L. Bernard as curator. Collection d is maintained at Ames, Iowa, with R. G. Palmer as curator.

D) Manuscript review and genetic symbol approval.

The Soybean Genetics Committee requests that researchers submit all manuscripts involving genetic symbols to the Committee Chairman. This review by the Genetics Committee will serve to avoid conflict of symbols and will help to insure orderly identification and use of genetic nomenclature. This will also allow assignment of type collection designations (T-numbers) prior to publication, so that these T-numbers may be used in the journal article to identify parental lines.

E) Soybean Genetics Newsletter notes.

All notes for the Newsletter should be sent to R. G. Palmer, who will ask the Soybean Genetics Committee to review those articles that concern genetic symbols. These symbols, reported in the Newsletter, will have the same status as those published in scientific journals.

Rules for Genetic Symbols

[At the Memphis, Tennessee meeting, the Committee changed the symbol for trisomics from Tris to Tri.]

I) Gene Symbols

a) A gene symbol shall consist of a base of one to three letters, to which may be appended subscripts and/or superscripts as described below.

b) Genes that are allelic shall be symbolized with the same base letter(s) so that each gene locus will be designated by a characteristic symbol base.

c) The first pair of genes reported for a gene locus shall be differentiated by capitalizing the first letter of the symbol for the dominant or partially dominant allele. (Example: Ab, ab. Ab is allelic and dominant to ab.) If genes are equivalent, codominant, or if dominance is not consistent, the capitalized symbol may be assigned at the author's discretion.

d) When more than two alleles exist for a locus, the additional alleles or those symbolized subsequently to the pair first published shall be differentiated by adding one or two uncapitalized letters or a number as a superscript to the base. (Example: R, r^m, r.) This shall be the only use of superscripts. The base for the additional alleles is capitalized only when the gene is dominant or equivalent to the allele originally designated with a capitalized symbol. The superscript may be an abbreviation of a descriptive term. When allelism is discovered for a gene previously assigned a symbol, the previous symbol may be used as the superscript.

e) Gene pairs with the same or similar effects (including duplicate, complementary, or polymeric genes) should be designated with the same letter base differentiated by numerical subscripts, assigning 1, 2, 3, 4, etc., consecutively in the order of publication. (Example: The y series for chlorophyll deficiency.) This shall be the only use of subscripts. Letter subscripts should not be used. The subscript 1 is

automatically a part of the first reported gene symbol for each base but may be omitted until the second symbol is assigned.

f) Base letters may be chosen so as to indicate apparent relationships among traits by using common initial letters for all loci in a related group of traits. Examples are *P* for pubescence type, *R* for disease reaction (plus two initials of the pathogen to complete the base), and *L* for leaf shape.

g) The distinction between traits that are to be symbolized with identical, similar, or with unrelated base letters is necessarily not clear cut. The decision for intermediate cases is at the discretion of the author but should be in accordance with previous practices for the particular type of trait. The following sections concern supplementary symbols that may be used whenever desired as aids to presentation of genetic formulas.

h) A dash may be used in place of a gene symbol to represent *any* allele at the indicated locus. The locus represented should be apparent from its position in the formula. (Example: *A*– represents both *AA* and *Aa*.)

i) A question mark may be used in place of a symbol when the gene is *unknown* or *doubtful*, or it may be used as a superscript to the base symbol for the same purpose. (Example: $a^?$ indicates that the latter is an unknown allele at the *A* locus.)

j) Plus symbols may be used in place of the assigned gene symbols of a designated standard homozygous strain when this will facilitate presenting genetic formulas. The standard strain may be any strain selected by the worker, as long as the strain being used and its genetic formula are made explicit.

II) Linkage and Chromosome Symbols

a) Linkage groups and the corresponding chromosomes shall be designated with Arabic numerals. Linkage shall be indicated in a genetic formula by preceding the linked genes with the linkage group number and listing the gene symbols in the order that they occur on the chromosome.

b) Permanent symbols for chromosomal aberrations shall include a symbol denoting the type of aberration plus the chromosome number(s) involved. Specific aberrations involving the same chromosome(s) shall be differentiated by a letter as follows: The symbol Tran shall denote translocations. Tran 1-2a would represent the first case of reciprocal translocations between chromosomes 1 and 2, Tran 1-2b the second, etc. The symbol Def shall denote deficiencies, Inv inversions, and Tri primary trisomics. The first published deficiency in chromosome 1 shall be symbolized as Def 1a, the second as Def 1b, etc. The first published inversion in chromosome 1 shall be denoted as Inv 1a, etc. The first published primary trisomic shall be designated with the Arabic numeral that corresponds to its respective linkage group number.

c) Temporary symbols for chromosomal aberrations are necessary, as it may be many years before they are located on their respective chromosomes. Tran 1 would represent the first case of a published reciprocal translocation; Tran 2, the second case, etc. The first published deficiency shall be symbolized as Def A, the second as Def B, etc. The first published inversion shall be symbolized as Inv A, the second as Inv B, etc. The first published primary trisomic shall be designated as Tri A, the second as Tri B, etc. When appropriate genetic and/or cytological evidence is available, the temporary symbols should be replaced with permanent symbols, with the approval of the Soybean Genetics Committee.

III) Cytoplasmic Factor Symbols

a) Cytoplasmic factors shall be designated with one or more letters prefixed by cyt-. (Example: cyt-G indicates the cytoplasmic factor for maternal green cotyledons, cyt-Y indicates that for maternal yellow cotyledons.)

IV) Priority and Validity of Symbols

a) A symbol shall be considered valid only when published in a recognized scientific journal, or when reported in the Soybean Genetics Newsletter,

with conclusions adequately supported by data which establish the existence of the entity being symbolized. Publication should include an adequate description of the phenotype in biological terminology, including quantitative measurements wherever pertinent.

b) In cases where different symbols have been assigned to the same factor, the symbol first published should be the accepted symbol, unless the original interpretation is shown to be incorrect, the symbol is not in accordance with these rules, or additional evidence shows that a change is necessary.

V) Rule Changes

a) These rules may be revised or amended by a majority vote of the Soybean Genetics Committee.

IV. RESEARCH NOTES FROM CONTRIBUTORS

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1) New pigments in soybean seedcoats.

Pigments were extracted from self-colored soybean seedcoats and subjected to standard procedures of paper chromatography. This research was a part of a Master's Thesis problem conducted by Barksdale Taylor on genetic and chemical evaluation of hilum variants in mature soybean seed. Brown, reddish brown and buff seedcoats did not contain anthocyanin pigments. It has been suggested that the pigment in brown seedcoats is either a phlobaphene (Nagai, 1921) or a leucoanthocyanin polymer (Koshimizu and Iizuka, 1963). Kuroda and Wada (1935) reported that the anthocyanin, cyanidin 3-monoglucoside, is the pigment in black seedcoats. Our research with 11 self-black cultivars confirmed that Cy 3-mgl was the major pigment but other bands of pigment also were present on the chromatograms. When L67-3469, a self-black 'Clark' isoline was used, a small band of orange pigment preceded the red band of Cy 3-mgl and two bluish-purple bands followed the red band.

An orange pigment was extracted from T236, which has a reddish buff seedcoat. Chromatography revealed that only one pigment was present. Partial hydrolysis of the pigment yielded only the anthocyanin and the aglycone, showing that the pigment is a monoglycoside. The soybean anthocyanin, aglycone and sugar were co-chromatographed with known compounds. The soybean anthocyanin and known pelargonidin 3-monoglucoside had Rf values of .40 with BAW, .33 with BuHCl, .13 with 1% HCl and .38 with HAc-HCl. The aglycone and known pelargonidin had Rf values of .84 with BAW, .40 with Formic and .76 with Forestal. The sugar had Rf values of .98 with IPrAq, .99 with IPrBu and .98 with PrEtAc. Composition of solvents for the anthocyanin and aglycone was described by Harborne (1967) and the solvents for the sugar by Smith (1960). The soybean anthocyanin in MeOH-HCl had an absorption max at 507 mμ and the aglycone in MeOH-HCl had an absorption max at 521 mμ. On the basis of these data, the soybean pigment was identified as pelargonidin 3-monoglucoside. The orange pigment in L67-3469 may also be Pg 3-mgl but this has not

been proven.

A bluish-purple pigment was extracted from seedcoats of L68-2073, a self-imperfect black Clark isoline. Paper chromatography revealed only one band of pigment. This band may be the same pigment as one of the bluish-purple bands in L67-3469, but more research is needed to prove or reject this hypothesis.

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1) Soybean breeding in Austria.

Introduction: Since Brillmayr (1929) published his first report on soybeans, there has been almost no intensive research on it in Austria. Its cultivation dropped gradually and then ceased completely after World War II, due to the increased import of American soybean products and the difficulty in producing varieties which suit Austrian conditions.

In 1970, the Institute of Agronomy and Plant Breeding, University of Agriculture, Vienna, started to renew interest in soybean and worked out a program to develop its cultivation, aiming to insert it as a suitable leguminous plant in the crop rotation, and to benefit from this rich source of

protein badly needed for animal and human nutrition.

The first problem was to find suitable varieties with a short vegetation period, not longer than 140 days; a high enough yield to be profitable for the producers; and good seed quality to fulfill the industrial requirements.

The investigations were carried on at the Institute's nursery in Vienna, and its Research Station in Großenzersdorf (25 Km from the University, 48°12' latitude, 16°34' longitude, elevation 153 m, mean rainfall per year 578 mm and the mean annual temperature 9.8°C).

The breeding program consists of: I — Germplasm collection: Since soybean is considered as an almost new crop in Austria, collection of introduced varieties formed a fundamental part of the breeding work. About 150 introductions from different countries (USA, Sweden, Japan, Brasil, Nigeria, Hungary, Czechoslovakia, Yugoslavia and West Germany) have been evaluated extensively and the promising entries were selected to form the basis of the major part of the breeding material. The local Austrian varieties introduce a very small portion of the genetic variability required for any breeding program and are impossible to depend upon.

II — Improving the agronomical treatments: The promising material was introduced in different field trials to evaluate its reaction to different agronomical treatments such as: way and method of sowing, plant density, time of sowing, depth of seeds, inoculation with bacteria, insecticides, herbicides, effect of temperature, photoperiod and supplementary irrigation on seed germination and yield potential, etc. The importance of such investigations is to throw light upon the norm of reaction of each entry "genotype", and to find out the best agronomical and environmental combinations which enable the genotype to express its maximum potential. Time of sowing, for example, affects the onset of blooming but not the ripeness and the harvest time. Early sowings gave the best results (Gretzmacher, 1974).

III — Selection: As already mentioned, since soybean is an almost new crop in Austria, simple and bulk selection from entries constitutes the major part of the work. The first information about any entry is always derived from single plants grown in single row plots. Promising simple or bulked plants were selected for further comparison trials using Latin square or randomized complete block design. In general, major emphasis was placed on

early maturity, yield, height, phenotypical seed quality, resistance to shattering and diseases, seed size, number of seeds per pod and number of pods per plant. No attention is being paid at present to the chemical composition.

IV—Induction of mutations: Three groups of seeds of different varieties were subjected to different dosages of X-rays during the period from 1970 until 1975, which can be summarized as follows:

1) Seeds of the German variety 'Caloria' "class 00" were treated in 1970 with 400, 600, 4000, 8000 and 12000 rad radiation, under the direction of the Atomic Research Center in Seibersdorf, Austria. Selection within and between the initial 60 strains was practiced annually for the characters previously mentioned. Out of this group of strains, only nine were still promising in 1975 and in the M_6 comparison trials. Minimum phenotypic differences were found between the selected strains and the original material. The relative degree of yield potential among strains was not consistent between successive generations. Besides controlled selection, the climatic conditions in the years during which the different generations were advanced resulted in extremely effective natural selection for maturity. Weiss, Weber and Kalton (1947) explained the inconsistency in yield potential among different breeding generations to be due to the late maturity which is alternately correlated with high or low yield depending upon seasonal conditions. In a collection of mutants selected for early blooming habit, it was noticed that the seasonal differences, especially thermophile, affect the blooming time more than the ripeness, and consequently the harvest time. These two characters seem to be independently directed; i.e., under warm environmental conditions these selected strains start to bloom earlier than under cold conditions, but the ripening time is still about the same. Johnson, Robinson and Comstock (1955) found that genotypic correlation between high yield and long period from flowering to maturity, lateness, heavy seed, resistance to shattering and lodging were appreciable in magnitude and suggested that they may be of practical value in selecting for high yield. Under Austrian conditions, it was noticed that multidimensional selection is slow but promising. In the following year some of the selected strains gave as high yield as 150% of the original control variety. This sudden increase had never been reached. Three superior strains are recognized as: ST 31, ST 53 and ST 59, and gave 151.5, 166.9 and 166.2% of the original mother sample's yield.

2) Seeds from four varieties, 'Caloria,' 'Altona,' 'Anoka,' and 'Portage,' were subjected to X-rays with dosages ranging from 12000 to 32000 rad. The highest doses were almost 50% lethal. The technique used and the characters selected were the same as in 1970. Two promising strains were obtained, AL 7202 and Ca 7218, which gave 115.7 and 108.0%, respectively, of the yield of their original ancestors. The differences in yield potential seem to be less heritable than those of other characters valuable to breeding purposes (Johnson, Robinson and Comstock, 1955a).

3) In 1975, seeds from another four varieties, 'Swift,' 'OS-289' (Yugoslavia), 'Manchu Wisconsin' and 'Iregi-Szürkebaralh' (Hungary), were subjected to another combination of X-ray dosages between 4000 and 16000 rad. These seeds will be sown this year.

V—Hybridization: Last year, 1975, some entries drew attention by being superior in one or more characteristics. A hybridization scheme was drawn, single plants were grown in pots, kept under glass house conditions with supplementary light to encourage blooming and normal growth. Crosses between some extreme plants were carried out. The number of suitable flowers was too little and about 60 crosses were completed. The F_1 seeds were sown the following summer under screen house conditions. The desired combinations were not yet found. F_2 seeds were harvested, and weighed but no segregation in seed coat color was observed. In the same summer of 1975, a large scheme program of crossing was planned and carried out. Five lines, single plants of 10 different entries and varieties, were sowed on two different sowing dates to elongate the blooming time and have a continual supply of flowers. About 300 crosses were made, representing almost all possible combinations. About 30 crosses were finally harvested. The F_1 seeds will be sown this year under screen house conditions. Major attention will be paid to back crossing the F_1 plants superior in the required characters. A normal large program for hybridization is scheduled for this year.

Summary: After a period of three decades, attention and interest has been renewed in soybean cultivation and breeding in Austria. The main problem is to find out the suitable initial material for breeding. This was practiced with the help of:

1) Germplasm collection from different countries.

2) Selection between and/or within introductions, especially for short

vegetation period to suit Austrian climatic conditions, plus the other economic characteristics.

3) Induction of mutations.

4) Hybridization.

Some strains originated by irradiation appear to be promising under the Austrian climate and seeds in small quantities are available for exchange.

Selection for yield from normal introductions seems to be also hopeful in spite of the difficulties cited above. The yield in comparison trials showed that the maximal yield increase obtained during the period 1970-1975 was about 15-24% due to varietal adaptability.

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1) Soybean linkage and allelism tests.

F_2 linkage results are presented in Table 1 with a = XY, b = Xy, c = xY, and d = xy for the gene pairs listed in the form of Xx and Yy. Percentage recombination was obtained as previously (Buzzell, 1974).

As reported previously (Buzzell, 1975), the T31 that I am using appeared to carry ln in contrast to the Ln T31 used by Weiss (1970). The F_2 results (Table 2) show that my T31 is ln the same as T41 which carries ln (Bernard and

Weiss, 1973) and the same as T109 and T204. This material was grown in a glasshouse during the spring of 1975 to obtain good growing conditions free of insects. A month after planting, the length (L) and width (W) of the terminal leaflet of the third trifoliolate (which was fully expanded) from the cotyledonary node was measured on each plant. The L/W ratios of ln puberulent plants were intermediate between those of broad- and narrow-leafed pubescent plants. This suggests that p_2 has a pleiotropic effect on leaf shape of ln plants.

My results indicate that the variety 'Midwest' carries dt_1. A determinate selection, OX303, from OX250 x OX383 (where OX250 is a determinate selection from 'Blackhawk' x 'Midwest') crossed to a determinate selection from 'Arksoy' x 'Blackhawk' resulted in only determinate F_2 and F_3 progeny.

Table 1

Soybean F_2 linkage tests

Genes	a	b	c	d	Sum	% R	SE	Phase
			OX281 (w_1w_1wmwm) x Beeson (W_1W_1WmWm)					
W_1w_1 Wmwm	333	6	4	107	450	2.2	0.5	c
		Harwood ($EpEpL_2L_2$) x Tokachishiro ($epepl_2l_2$)						
Epep L_2l_2	146	42	41	11	240	51.0	3.3	c

Table 2

Soybean F_2 allelism tests

Parent or cross	Number of plants				L/W ratio	
	Broad	: Narrow	Pubescent	: Puberulent	Pubescent	: Puberulent
T31	0	25	0	25		1.96
T41	0	11	11	0	2.81	
T109	0	11	11	0	2.59	
T204	0	9	9	0	2.59	
T31 x T41	0	96	77	19	2.80	2.23
T31 x T109	0	95	76	19	2.68	2.09
T31 x T204	0	95	63	32	2.58	2.00
Blackhawk	10	0	10	0	1.50	
Midwest	10	0	10	0	1.72	
Blackhawk x Midwest	65	0	65	0	1.59	

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1) Determinate-Dt_2 effects on soybean characteristics.

Bernard (1972) studied a gene, Dt_2, which hastened the termination of apical stem growth and decreased both plant height and number of nodes per plant. In a 'Harosoy' background, a Dt_2 isoline had a 15% reduction in height and was three days earlier maturing but was similar in yield to Harosoy. There was some reduction in weight per seed associated with the Dt_2 effect. We have worked with the Dt_2 gene in a Harosoy background and have obtained an even greater effect on plant height, maturity, and weight per seed but yet have maintained yield. It appears that there might be another gene involved which interacts with Dt_2.

The cross, L62-361 (Harosoy^6 x T117) x L59-738 ('Harosoy 63'), was made at Harrow in 1965 to combine Dt_2 with Rps_1. In selecting for a resistant, determinate line, we selected for maturity as close to Harosoy 63 as possible. Another line was selected which was six days earlier than L62-361. These two determinate lines, OX708 and OX719, were tested with Harosoy 63 at Harrow and Woodslee (1971-73) and at Ridgetown (1974) in replicated row tests. Results are given in Table 1.

A growth analysis test was conducted at Harrow in 1973 with samples taken every two weeks beginning July 3 (25 days after planting). On July 16, OX708, OX719, and Harosoy 63 averaged 8, 6, and 3 flowers per plant, whereas on July 30 they averaged 35, 30, and 20 flowers per plant. There were no

differences (from 9 to 10 flowers) on August 13, at which time maximum plant height had been reached. Results of the sample for this date are given in Table 2, along with the average results for two samples at maturity. 0X708 differed significantly from 0X719 in being earlier maturing and having less weight per seed. In other characteristics these two lines were fairly similar but 0X708 tended to differ more from Harosoy 63 than did 0X719.

We postulate that 0X719 received $\underline{Dt}_2$ plus another gene from L62-361 and that 0X708 received $\underline{Dt}_2$ from L62-361 but a different allele from L59-738 for the other gene. On the basis of this hypothesis, 0X708 and 0X719 have been backcrossed to L59-738 for further study; the cross with 0X708 should not segregate for maturity within the $\underline{Dt}_2$ class whereas the cross with 0X719 should segregate.

The "early-determinate" characteristic of 0X708 has distinct effects on leaf and podding characteristics compared with Harosoy 63. Early-determinate has been combined with <u>ln</u> for further study in relation to narrow leaflets and 4-seeded pods. We have used 0X708 in a number of crosses and will attempt to select early-determinate strains as a means of increasing the yield-maturity index.

Table 1

Row test results for $\underline{Dt}_2$ isolines of Harosoy 63

	Yield kg/ha	Days to mature	Yield maturity index[a]	Lodging 1 = Erect 5 = Flat	Plant height cm	g/100 seeds
			Harrow and Woodslee, 1971-73			
0X708	3216	114	28	1.9	93	18.1
0X719	3215	117	27	1.6	91	19.2
Harosoy 63	3048	121	25	2.6	106	19.6
L.S.D.(.05)	N.S.	1	2	0.3	5	0.7
			Ridgetown, 1974			
0X708	2986	123	24	1.5	96	15.9
0X719	3188	127	25	1.2	99	17.9
Harosoy 63	2946	131	22	1.7	114	18.8

[a]Yield-maturity index = yield (in kg/ha)/days to mature.

Table 2

Growth analysis results for $\underline{Dt}_2$ isolines of Harosoy 63

	August 13 (76 days after planting)				At Maturity			
	0X708	0X719	Harosoy 63	L.S.D. .05	0X708	0X719	Harosoy 63	L.S.D. .05
Plant height, cm	105	108	116	6	100	104	116	9
No. of pods/plant								
1-seeded	2	2	1	-	3	3	2	-
2-seeded	9	9	6	-	9	9	7	-
3-seeded	11	10	10	-	8	7	8	-
Total	22	21	17	-	20	19	17	-
Pod dry wt, g/plant	3.0	2.6	2.0	0.5	9.9	10.2	10.8	N.S.
Leaves/plant	8.0	7.4	8.0	N.S.	-	-	-	-
Leaf area, cm^2/plant	1180	1254	1402	125	-	-	-	-
Leaf area index	4.4	4.9	5.4	0.6	-	-	-	-
Leaf area ratio	4.04	3.48	3.44	0.46	-	-	-	-
Nodes/plant	-	-	-	-	14	14	15	-
Pods/node	-	-	-	-	1.5	1.4	1.2	0.16
Beans/node	-	-	-	-	3.2	3.0	2.8	N.S.
Yield, kg/ha	-	-	-	-	2880	2770	2870	N.S.

Reference

Bernard, R. L. 1972. Two genes affecting stem termination in soybeans. Crop Sci. 12: 235-239.

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AGRICULTURE CANADA
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1) Soybean gene resources recently received from China.

Forty soybean cultivars were received from the Peoples Republic of China in a number of exchanges between June 1973 and June 1974. The first eight cultivars that we received were grown in row tests at Harrow, Woodslee and Ridgetown in 1975, along with 'Harlon,' 'Harosoy 63,' and 'Harcor.' These eight, plus the next seven that we received, had been tested in hill plots at Harrow in 1974, along with Hardome, Harlon, Harosoy 63, and 'Harwood.' The highest and lowest cultivar values are given for each of a number of characteristics within each group of cultivars as an indication of the potential value of the new germplasm. The Chinese cultivars did not exceed those from Harrow in productivity. Although plant height tended to be shorter, lodging was more of a problem with the Chinese cultivars in row culture than with the Harrow cultivars.

Of the 40 cultivars, some were determinate and 12 had narrow leaves, in contrast to the indeterminate Harrow cultivars which have broad leaves. Only four cultivars carry Rps_1 resistance to race 1 of *Phytophthora megasperma* var. *sojae*, with none having specific resistance to the new races. However, of the eight cultivars grown in 1975 at Woodslee where race 6 is prevalent, all were as field tolerant as Harcor which was considerably better than Harlon and Harosoy 63. This germplasm is being tested as a source of polygenic variability for resistance to phytophthora rot.

Table 1

Ranges for groups of Chinese and Canadian (Harrow) soybean cultivars

	1974 Hill Test				1974 Row Tests			
	Chinese		Canadian		Chinese		Canadian	
	Low	High	Low	High	Low	High	Low	High
Days to flower	37	48	37	40	-	-	-	-
Days to mature	104	121	101	117	114	131	112	126
Yield	81[a]	185	127	205	2420[b]	2970	2600	3000
Yield-maturity index	0.78	1.53	1.26	1.76	19	24	23	24
Lodging	1.8	3.2	2.5	3.0	2.8	4.2	1.8	2.7
Plant height, cm	59	95	85	105	72	86	81	96
g/100 seeds	15.9	22.4	16.3	19.8	14.8	20.2	14.5	16.0
P_A	30.2	35.7	33.7	36.7	-	-	-	-
% beans	48.8	57.3	52.0	54.1	-	-	-	-

[a] Grams per plot.

[b] Kilograms per ha.

Yield-maturity index = Yield (in grams/plot or kg/ha)/days to mature.

Lodging: 1 = Erect, 5 = Prostrate.

P_A = photosynthetic rate (mg $CO_2/dm^2/hr$) measured at early flowering stage.

% beans = bean weight x 100/mature plant (top) weight.

Copies of cultivar descriptions and results are available from the Harrow Research Station, and seeds of the 15 cultivars grown in 1974 are available from The Plant Gene Resources of Canada.

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1) Genetic studies of soybean host cultivar interactions with Rhizobium strains.

Several genetic factors have been identified which govern specific nodulation response in soybeans. The Rj_2 genotype, carried by the cultivars 'Hardee' and 'CNS,' conditions an ineffective response in specific combination with *Rhizobium japonicum* strains of serogroups c1 and 122. The ineffective response is characterized as the development of either cortical proliferations on the roots or rudimentary nodules, rather than normal nodules. The Rj_3 genotype, carried by the cultivar Hardee, conditions an ineffective response in combination with strain 33; and the Rj_4 genotype, carried by the cultivars 'Hill,' 'Dunfield,' and 'Dare,' conditions an ineffective response with strain 61.

In monitoring the presence of these genes in the germplasm now used in the production of soybeans in the U.S., the cultivars in Table 1 were tested, by the leonard jar technique, against *Rhizobium* strains defining for the presence of several *Rj* factors: strain 7 (of serogroup c1) for Rj_2, strain 33 for Rj_3, strain 61 for Rj_4. Strain 123 was included because of its aberrant reaction with the cultivar 'Peking.' Strain 110 was included as a check.

The results indicate that the cultivars 'Lee' and 'Davis' exhibit the Rj_3 phenotype. Both Lee and Davis have pedigrees which involve CNS. In other tests we have found that CNS also carries the Rj_3 gene as well as Rj_2. In this test 'Amsoy 71' exhibits the Rj_4 phenotype. 'Tracy' is heterogeneous

for the Rj_4 phenotype, with some plants nodulated normally and others displaying the ineffective response. The pedigree of Amsoy 71 involves Dunfield, the putative source of the Rj_4 gene. The pedigree of Tracy involves Hill as the putative source of the Rj_4 gene.

Cultivars	Maturity group	Rhizobium strains 7	33	61	110	123	Uninoculated check
Hodgson	I	NOD	NOD	NOD	NOD	NOD	Not nodulated
Amsoy 71	II	NOD	NOD	Ineffective	NOD	NOD	Not nodulated
Corsoy	II	NOD	NOD	NOD	NOD	NOD	Not nodulated
Williams	III	NOD	NOD	NOD	NOD	NOD	Not nodulated
Bonus	IV	NOD	NOD	NOD	NOD	NOD	Not nodulated
Forrest	V	NOD	NOD	NOD	NOD	NOD	Not nodulated
Tracy	VI	NOD	NOD	Ineffective[a]	NOD	NOD	Not nodulated
Lee	VI	NOD	Ineffective	NOD	NOD	NOD	Not nodulated
Davis	VI	NOD	Ineffective	NOD	NOD	NOD	Not nodulated
Bragg	VII	NOD	NOD	NOD	NOD	NOD	Not nodulated

NOD = normal nodulation.
Ineffective = Cortical proliferations or rudimentary nodules rather than normal nodules are formed on the roots.
a = Heterogeneous population.

References

Caldwell, B. E. 1966. Inheritance of a strain-specific ineffective nodulation in soybeans. Crop Sci. 6: 427-428.

Vest, Grant. 1970. Rj_3-a gene conditioning ineffectiveness in soybeans. Crop Sci. 10: 34-35.

Vest, Grant and B. E. Caldwell. 1972. Rj_4-a gene conditioning ineffective nodulation in soybean. Crop Sci. 12: 692-694.

Vest, Grant, D. F. Weber and C. Sloger. 1972. Nodulation and nitrogen fixation. In B. E. Caldwell (ed.). Soybeans: Improvement, production, and uses. Am. Soc. Agron., Madison, Wisconsin. pp. 353-390.

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2) Vegetative propagation of soybeans.

During the course of genetic studies of possible linkage associations involving factors controlling nodulation response in soybeans, we found it desirable to increase the size of the F_2 population produced in the greenhouse during the winter. We endeavored to do this by vegetatively propagating the F_1 hybrid plants for use in seed production. We visualize that vegetative propagation would also be useful for other purposes: (1) maintaining aneuploids which segregate at meiosis, and (2) providing propagules which may be subjected to different photoperiod regimes, thus providing coincidence of flowering in crosses of uncertain maturity when little seed is available. In a search of recent publications, we have been unable to find a technique describing procedures for vegetative propagation of soybeans. We tested the following procedure for rooting of cuttings.

Greenhouse plants of the cultivar 'Clark' were used as stock material for cuttings. The cuttings, 8 to 10 cm long with two or three nodes, were taken from the mid-section of 75-day old plants. Smooth clean cuts were made with a scalpel 0.5 cm below the lower node. One trifoliate leaf remained on the upper node of the cutting. No root promoting compounds were applied.

Two rooting media were used, coarse perlite and vermiculite. The media were held in a wooden flat 35 x 50 x 10 cm and placed under a continuous fine mist. Cuttings were implanted in the medium to a depth of 7 to 9 cm (internode length) leaving a trifoliate and a portion of the stem uncovered. Twenty-one days after implanting, the cuttings were removed from the media.

Both media provided satisfactory rooting. Fifty-two cuttings of the 56 attempted (94%) developed a root system. The roots of the cuttings in perlite were thicker and more numerous with more lateral roots than the cuttings in vermiculite. Cuttings in vermiculite were finer and longer than those in perlite. Roots originated at both the node and internodal regions, above and below the basal node. However, roots developed most profusely at the node. Seventy-five percent of the cuttings rooted exclusively at the nodal area. The remaining 25% rooted along the internode as well as at the node. No prominent callus tissue or swelling was observed.

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1) Evidence of a second gene controlling a short internode (zigzag stem) character.

Kilen and Hartwig (1975) have described a short internode character found in PI 227.224 which causes a zigzag stem appearance. They indicated that the short internode character was probably determined by a single recessive gene pair based on classification of the presence or absence of the zigzag stem appearance. In the F_2 generations of the crosses, PI 227.224 x 'Coker 338' and PI 227.224 x 'Davis,' we observed two different ratios. In the first cross the segregation was 3 normal stem : 1 zigzag stem (724:229, expected 714:238, $\chi^2 P = .5 - .3$). In the PI 227.224 x Davis cross the ratio was 15 normal stem : 1 zigzag stem (765:58, expected 772:51, $\chi^2 P = .5 - .3$). This ratio differed from a 3:1 at the 1% level of probability (by the Chi-square test). The F_1 plants in both crosses had normal stem types. These data suggest that PI 227.224 and Davis differ by two recessive genes for this character. The F_3 generation of this cross will be evaluated during the summer of 1976. Crosses have been made to determine the relationship of the two recessive genes indicated in this cross and the single recessive gene indicated by Kilen and Hartwig (1975).

The F_2 generation of a third cross ('Jackson' x PI 227.224) was space planted. Jackson also appeared to differ from PI 227.224 by one recessive gene for this character. The average internode lengths (mean of the sixth and seventh internodes) were 2.2, 2.0, 1.6, and 2.9 cm for the normal, zigzag, PI 227.224, and Jackson plants, respectively. This small difference in internode length (0.2 cm) between normal and zigzag stem types and the fact that normal stem plants were found with shorter average internode lengths than some of the zigzag stem plants suggest that the zigzag stem appearance may be due to some other anatomical characteristic. This possibility is also being explored.

Reference

Kilen, T. C. and E. E. Hartwig. 1975. Short internode character in soybeans and its inheritance. Crop Sci. 15: 878.

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1) Forage value of soybean plants.

Soybeans have been evaluated for a second year as to their contribution to silage quality when interplanted with *Zea mays*. In 1974, two forage cultivars ('Black Wilson' and 'Laredo') available in the local seed trade, and 'Amsoy 71' were interplanted with a number of sorghum-sudans, grain sorghums, and *Zea mays*. A number of protepeas (*Vigna unguiculata*) were also interplanted.

The forage soybeans increased dry matter yield over that of the grasses alone with or without nitrogen, or with protepeas in 1974. The soybeans flowered and set seed in the shade of the tall grasses much more readily than did the forage protepeas. With the first frosts in the fall the protepeas were killed, but the indeterminate forage soybeans increased growth.

Material harvested as silage in the fall of 1974 were subjected to quality evaluation by an artificial rumen technique (*in vitro* digestibility-IVD) and by crude protein analyses. IVD's of *Zea mays* and the *Zea mays*-legume combinations were far superior to that of the other mixtures in the study. The soybeans and protepeas both increased the crude protein content above that of *Zea mays* alone. Protein increase was greatest with the soybeans. However, *in vitro* digestibility of the mixture was significantly reduced by the soybeans whereas it was increased by the protepeas.

In 1975, *Zea mays* was planted alone or in combination with the two forage soybean cultivars used in 1974, plus wild soybean (*Glycine ussuriensis*) [Editor's note: now called *G. soja*], protepeas, and hyacinth bean, *Dolichos*

lab lab [Editor's note: now called Lablab purpureus] (Tifton #1). Even though Amsoy 71 soybean had good seed set in the 1974 study, its relative plant maturity tended to decrease quality below that of the green forage types so a grain variety was not interplanted the second year.

No legume-Zea mays planting combination significantly affected yield in 1975. A portion of each replication was hand harvested to determine the quality of leaf-stem-pod components of each interplanted legume. The components were analyzed not only for crude protein and IVD, but also for total cell wall, cellulose, and lignin. The amounts of each quality-component portion were then summed to give whole plant values (Table 1).

Table 1
Whole plant in vitro digestibility, crude protein, total cell wall, cellulose and lignin of soybean, protepea, and hyacinth bean forage

	IVD	CP	TCW	Cellulose	Lignin
Black Wilson soybean	55.6d[1]	19.3a	53.7ns	27.7a	14.4a
Laredo soybean	56.1d	16.8b	56.3	29.0a	13.0ab
Wild soybean[2]	(61.4)	(17.2)	(52.7)	(24.2)	(11.7)
New Era protepea	67.3b	10.7d	54.1	28.7a	11.8b
Whippoorwill protepea	71.1a	12.2cd	55.3	24.6b	10.4b
Hyacinth bean	60.9c	10.8d	55.7	29.0a	12.7ab

[1]Means followed by the same letter are not statistically different (.05) according to Duncan's Multiple Range Test.

[2]Wasn't included in statistical analyses as rabbits selectively grazed out most of each replicate, and regrowth material was available from only two locations.

Stems of the soybean plants were quite high in lignin. Even though 34% of the dry matter was pods (seeds included), whole plant Black Wilson IVD was among the lowest of the legumes tested (Table 1). Crude protein content, on the other hand, was superior to that of the other legumes, a result of the large seed component. Total cell wall was not different between the legumes, and only one protepea cultivar had a lower cellulose content (Table 1).

The low whole plant quality of the soybeans was not only a reflection of high stem fiber but also a reflection of high leaf fiber. The better quality of the wild soybean was due to the young growth which finally occurred at the end of the summer as rabbit pressure eased. Rabbits and deer selectively browsed the soybeans and neglected the protepeas in both 1974 and 1975. The apical, meristemic regions of the growing soybean plant are apparently quite acceptable even though the rest of the plant is highly fibrous.

Use of the leafy, small-vined G. soja in 1975 was an effort to improve protein while retaining the in vitro digestibility of Zea mays silage. Perhaps other soybean types, possibly the edible or non-pubescent types, may have less plant fiber.

Reference

Gupta, B. S., D. E. Johnson, F. C. Hinds and H. C. Minor. 1973. Forage potential of soybean straw. Agron. J. 65: 538-541.

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1) Determination of sugar content of individual soybean seeds.

In order to investigate the possibility of single seed selection for sugar content in soybeans, a technique has been developed for analysis of 20-40 mg samples of soybean meal. The method described by Hymowitz et al. (1972) has been modified to serve this purpose.

A portion of a soybean seed is ground for 5 min in a ball mill (Spex Industries, Inc.). A 40 mg sample of meal is weighed and wrapped in 7½ cm Whatman filter paper (No. 50). The package is then bound tightly with wire. Lipids are extracted by refluxing for 24 hr with petroleum ether (bp 30-60 C) in a Soxhlet extraction apparatus. The defatted meal is then transferred to a 16 x 125 mm screw-capped culture tube and .5 ml (2.5 mg) of gentiobiose solution is added as an internal standard. The volume is brought to 5 ml

with 80% ethanol and the tube is shaken on a Super Mixer (Matheson Scientific). The sample is heated in a 75 C water bath for 1 hr, being shaken every 10 min. The solution is then transferred to a 50 ml beaker. The meal is washed four times with 5 ml of 80% ethanol, the washings being combined with the original transfer. The sugar solution is evaporated to low volume (about 3 ml) and transferred to a clean culture tube. Protein is precipitated with 6 drops of lead acetate, and 6 mg of sodium bicarbonate is added to remove excess lead. The sample is then centrifuged at 2000 g for 15 min and decanted into a 15 x 45 mm shell vial. The pH is adjusted to 5.7-6.3 with 3.4 M acetic acid and the sample is then evaporated to complete dryness. Derivitization and GLC settings are as described by Hymowitz et al. (1972) with the following exceptions: carrier flow rate, 30 cc/min; carrier makeup, 90 cc/min; column temperature rise from 150-330 C over an 8 min rise time, preceded by a hold time of 2.4 min at 150 C.

Reference

Hymowitz, T., F. I. Collins, J. Panzner and W. M. Walker. 1972. Relationship between the content of oil, protein, and sugar in soybean seed. Agron. J. 64: 613-616.

S. J. Openshaw
T. Hymowitz
H. H. Hadley

2) Inheritance of a second SBTI-A_2 variant in seed protein of soybeans.*

The soybean trypsin inhibitor (SBTI-A_2) is a seed protein that exhibits different electrophoretic forms. Hymowitz and Hadley (1972) demonstrated that two different electrophoretic forms of SBTI-A_2 represent the expression of two codominant alleles at a single locus. They assigned the symbol Ti^1 to the allele controlling the most commonly occurring electrophoretic form Rf 0.79/10% (Rf = mobility relative to the dye front in a 10% polyacrylamide gel anodic system) and Ti^2 to the allele controlling the electrophoretic form found at Rf 0.75/10%. A third electrophoretic form of SBTI-A_2 Rf 0.83/10%

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was recently located in seed of PI 246.367 and PI 196.172 (Hymowitz, 1973). Data reported herein is concerned with the inheritance of Rf 0.83/10% electrophoretic form.

We crossed T245 (Rf 0.75, $\underline{Ti}^2$) with PI 246.367 (Rf 0.83). The F_1 seed had both electrophoretic forms. The pooled F_2 seed segregated 1 Rf 0.75 : 2 both forms : 1 Rf 0.83 (89:162:74, expected 81.5:163:81.5, $\chi^2 P = .54$). We crossed 'Harosoy' (Rf 0.79, $\underline{Ti}^1$) with PI 246.367 (Rf 0.83). The F_1 seed had both electrophoretic forms. The pooled F_2 seed segregated 1 Rf 0.79 : 2 both forms : 1 Rf 0.83 (42:101:57, expected 50:100:50, $\chi^2 P = .33$). In both crosses the data were pooled since the χ^2 analysis among families showed no heterogeneity.

From these data, we conclude that a gene, here designated $\underline{Ti}^3$, controls the electrophoretic form Rf 0.83/10% and that it has two codominant alleles $\underline{Ti}^1$ and $\underline{Ti}^2$ with which it forms a multiple allelic series controlling the three electrophoretic forms of SBTI-A_2.

References

Hymowitz, T. 1973. Electrophoretic analysis of SBTI-A_2 in the USDA soybean germplasm collection. Crop Sci. 13: 420-421.

Hymowitz, T. and H. H. Hadley. 1972. Inheritance of a trypsin inhibitor variant in seed protein of soybeans. Crop Sci. 12: 197-198.

James H. Orf

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3) The gene symbols $Sp_1{}^a$ and $Sp_1{}^b$ assigned to Larsen and Caldwell's seed protein bands A and B.*

Larson (1967), using acrylamide gel electrophoresis, described two seed proteins in soybean seed and noted they were variety specific. The inheritance of these proteins (although the proteins were not characterized) was reported as being controlled by two codominant alleles at a single locus (Larsen and Caldwell, 1968); gene symbols were not assigned. The letters "A" and "B" were used to designate the two different seed protein bands.

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*Research supported in part by grants from the Illinois Crop Improvement Association and the United States Agency for International Development under Contract No. AID/CM/ta-c-73-19.

Our studies using polyacrylamide gel electrophoresis revealed that the seed protein band called "A" by Larsen and Caldwell (1968) occurs at Rf 0.36/10% (Rf = mobility relative to the dye front in a 10% polyacrylamide gel anodic system) and the seed protein band called "B" occurs at Rf 0.42/10%. We crossed 'Cloud' (Rf 0.42) with 'Amsoy' (Rf 0.36). The F_1 seed had both electrophoretic forms. The pooled F_2 seed segregated 1 Rf 0.36 : 2 both forms : 1 Rf 0.42 (35:77:30, expected 35.5:71:35.5, χ^2P = .51). We propose the gene symbol base *Sp* for seed protein with subscript numbers to designate different proteins and superscript letters for codominant alleles controlling different forms of a protein. Thus, we propose Sp_1^a for the electrophoretic form Rf 0.36 and Sp_1^b for the electrophoretic form Rf 0.42. Sp_1^a should be the same gene for the "A" protein band studied by Larsen and Caldwell in Amsoy, and Sp_1^b probably corresponds to their gene for the "B" protein band.

References

Larsen, A. L. 1967. Electrophoretic differences in seed proteins among varieties of soybean, *Glycine max* (L.) Merrill. Crop Sci. 7: 311-313.

Larsen, A. L. and B. E. Caldwell. 1968. Inheritance of certain proteins in soybean seed. Crop Sci. 8: 474-476.

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Theodore Hymowitz

4) Glycine germplasm resources.

	Country	Curator	Address	Collection #	Comments
1)	U.S.A.	R. L. Bernard	U.S. Regional Soybean Laboratory Urbana, Illinois 61801	4700	Genetic types, varieties, *Glycine* species
2)	U.S.A.	E. E. Hartwig	Delta Branch Experiment Station Stoneville, Mississippi 38776	1400	Genetic types, varieties, *Glycine* spp. world-wide southern collection
3)	U.S.A.	T. Hymowitz	Department of Agronomy University of Illinois Urbana, Illinois 61801	----	Computer stored and data retrieval system for *Glycine* germplasm available in 1 and 2
4)	Taiwan	S. Shanmugasundarum	Asian Vegetable and Development Center, P.O. Box 42, Shanhua Tainan, Taiwan	9000	World-wide collection, many duplicates of the U.S. collection
5)	Taiwan	Chan Ko Leim	Taiwan Agricultural Research Inst. Taichung, Taiwan	2800	Mainly U.S. collection
6)	India	H. R. Bhatia	Plant Introduction Station Amravati, Maharashtra	1800	Nepal, Sikkim, India, and many other countries
7)	India	B. B. Singh	Department of Plant Breeding G. B. Pant University Pantnagar, Uttar Pradesh	4000	U.S.A., U.S.S.R., India, Japanese collection
8)	Sweden	S. A. Holmberg	Algot Holmberg and Soner AB Plant Breeding Station at Fiskeby 605 90 Norrkoping	1200	East and North Asia
9)	Nigeria	W. Steele	International Institute of Agriculture, Private Mail Bag 5320, Ibadan	2000	East Africa, Tanzania
10)	S. Korea	S. H. Kwon	Atomic Energy Research Institute P.O. Box 7, Cheong Kyang, Seoul	1300	Native land races
11)	S. Korea	K. Y. Park	Crop Experiment Station Office of Rural Development Suweon	300	*Glycine* species
12)	France	R. M. Ecochard	Ecole Nationale Superieure Agronomique, 145 Av. de Muret Toulouse	500	Bulgaria, Hungary, China, U.S.A.

	Country	Curator	Address	Collection #	Comments
13)	U.S.S.R.	N. I. Korsakov	Vavilov All Union Institute of Plant Industry, Gerzem 44 Leningrad	2500	East and North Asia
14)	Japan	T. Egawa	National Institute of Agricultural Sciences, Hiratsuka, Kanagawa Prefecture	2928	Mainly Japan
15)	Japan	J. Fukui	Plant Breeding Laboratory, Iwate University, Ueda, Morioka-city, Iwate Prefecture	200	*Glycine* species
16)	Peoples Republic of China	C. L. Wang	Northeast Agricultural College Harbin, Heilungkiang Province		Land races
17)	Peoples Republic of China	T. C. Chang	Institute of Crop Breeding Kirin Academy of Agriculture Sciences Kung-chu-ling City, Kirin Province		Land races
18)	Republic of South Africa	J. W. Snyman	Institute for Crops and Pastures Private Mail Bag 116 Pretoria	600	U.S. collection
19)	Rhodesia	R. Tattersfield	Ministry of Agriculture Causeway, Salisbury		

Additional Collections

Bulgaria, National Institute of Agriculture, Sofia

Romania, Agricultural Experiment Station, Fundulea

Indonesia, Institute Pertanian, Bogor

Philippines, College of Agriculture, University of the Philippines, College, Laguna

Hungary, Agricultural Experiment Station, Iregszemcse

Australia, CSIRO, Division of Plant Industry, P.O. Box 1600, Canberra City, A.C.T. 2601

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1) Inheritance in chlorophyll deficient mutants.*

Studies of chlorophyll deficient soybeans have shown that normal development of chlorophyll is controlled by several genes. The recent review by Bernard and Weiss (1973) summarizes information about the known published chlorophyll deficient lines. A number of soybean lines exhibiting chlorophyll deficiencies which have not been studied genetically are included in the genetic type collection maintained at the U.S. Regional Soybean Laboratory. Inheritance studies of two of these lines, T134 and T162, are reported in this paper.

Seeds of 3 F_1 plants of T134 x 'Clark-*k*' and 4 F_1 plants of T162 x Clark-*k* were obtained from the U.S. Regional Soybean Laboratory. They were planted in the field at the University of Puerto Rico Agricultural Experimental Substation at Isabela on June 13, 1974. The single gene recessive mutants from the type collection that are viable were also grown along with T134 and T162. Descriptions of the phenotypes of the parent lines follow:

Line	Seedling stage (8 days)	Beyond seedling stage
Clark-*k*	Normal green plant	Normal green (the seeds have a black saddle pattern from the mutant gene *k*)
T134	Cotyledon and primary leaves pale green	Entire plant very pale green; small, weak plant
T162	Cotyledon near normal green; primary leaves slightly mottled, light yellowish green	Entire plant light yellowish green; small plant

*This study was supported by the University of Illinois and the U.S. Agency for International Development under 211(d) grant AID/CM/ta-g-73-49.

At 12 days after planting (first trifoliate leaf expanding) the normal green plants and chlorophyll deficient plants were counted. Table 1 shows the segregation of normal and chlorophyll deficient plants in the F_2 generation. The observed results closely fit the expected 3:1 ratio.

Table 1

Observed and expected ratios in the F_2 segregating generation

Cross		No. of F_2 plants: Normal	No. of F_2 plants: Chlorophyll deficient	Chi-square probability
T134 x Clark-k	Observed	338	110	0.87
	Expected 3:1 ratio	336	112	
T162 x Clark-k	Observed	191	62	0.91
	Expected 3:1 ratio	189.75	63.25	

In the F_2 generation, 45 normal green plants and 30 chlorophyll deficient plants from each cross were harvested and the progenies were grown as single plant rows. The mean number of F_3 plants per normal green F_2 plant was 34 and ranged from 4 to 132 for T134 x Clark-k. For T162 x Clark-k, the mean number was 75 with a range of 12 to 167.

Results of the F_3 test are shown in Table 2. The 45 normal F_2 plants gave a ratio of approximately 1:2 for normal green progeny to progeny segregating both normal green and chlorophyll deficient. For total F_3 plants from segregating progenies, the observed was a close fit to the expected 3:1 ratio of normal green to chlorophyll deficient for both crosses.

All progenies from chlorophyll deficient F_2 plants showed the same phenotype as the F_2.

In order to test the relationship of these two genes with known genes of similar phenotypes, crosses were made in Puerto Rico with the lines which

Table 2

Observed and expected ratios in F_3 test from normal green and chlorophyll deficient F_2 plants

Cross	F_2 phenotype	No. of F_2 progenies: Observed	Expected	No. of F_3 plants: Normal	Chlor. def.	Chi-square probability
T134	Normal (homo.)	17	15	783	0	
x						
Clark-_k_	Normal (heter.)	28	30	obs.720	237	0.90
				exp.717.75	239.25	*
	Chlorophyll deficient	26	-	0	305	
T162	Normal (homo.)	10	15	903	0	
x						
Clark-_k_	Normal (heter.)	35	30	obs.1978	654	0.88
				exp.1974	658	*
	Chlorophyll deficient	30	-	0	619	

*Test of homogeneity among progeny.
T162 x Clark-_k_ (df = 34) χ^2P = .54
T134 x Clark-_k_ (df = 27) χ^2P = .35

are homozygous for recessive chlorophyll deficiencies. The F_1 hybrids were planted in 6 inch pots and were grown to maturity in the University of Illinois agronomy greenhouse at Urbana. Table 3 shows the number and phenotype of the F_1 plants. All crosses produced normal green F_1 hybrids with the exception of T134 x T116 ($\underline{y_5}$). This F_1 hybrid appeared identical in color to T134 and T116 plants. These plants were slightly more vigorous than T134 and much more than T116 which is an extremely small weak plant. The T134 x T116 hybrids were purple flowered, showing the dominance of T116 purple flower ($\underline{W_1}$) over T134 white flower ($\underline{w_1}$). All crosses will be progeny tested.

From the data, it appears that in line T162 chlorophyll deficiency is caused by a single recessive gene independent of all previously reported

Table 3

Phenotype of F_1 plants from chlorophyll deficient line crosses

Genotype	Parent strain P_2	No. of F_1 plants: P_1 : T134 Normal	P_1 : T134 Chlorophyll deficient	P_1 : T162 Normal	P_1 : T162 Chlorophyll deficient
y_4	T102	12	0	13	0
y_5	T116	0	6	6	0
y_6	T136	-[b]	-	3	0
y_9	T135	3	0	2	0
y_{10}	T161	9	0	7	0
y_{12}	T233	10	0	5	0
y_{13}	T230	5	0	3	0
y_{14}[a]	T229	6	0	9	0
y_{15}[a]	T234	9	0	8	0
	T134	-	-	3	0
	T162	8	0	-	-

[a]Unpublished.

[b]Cross is presently being made.

genes. The symbol y_{17} is here assigned to this gene. T134 may carry the single recessive y_5 gene reported in T116 by Morse and Cartter (1937), or the chlorophyll deficiency may be caused by a third gene at the same locus. Further study is necessary to clearly establish this relationship.

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1) Polyploids among the progeny from male sterile ($\underline{ms_1ms_1}$) soybeans.*

Last year we reported that sterility in three male sterile mutants (Ames, Harosoy, and Urbana) was controlled by a single recessive gene at the $\underline{ms_1}$ locus (Palmer and Winger, 1975). Our results with the Urbana male sterile are in agreement with those of Cooper and Boerma (1975). In allelism tests with the North Carolina $\underline{ms_1}$ mutant, several of the sterile testcross progeny had a few seeds. These testcross plants were grown in the greenhouse where pollinating vectors seemed to be absent.

The selfed progeny from these sterile plants had 40 chromosomes, except for one plant which had 140 chromosomes. We therefore checked chromosome number of all twin seedlings and abnormal seedlings from 251 seeds collected in 1972 and 1973 from field-grown Harosoy male sterile plants (Table 1).

Table 1
Progeny from Harosoy sterile ($\underline{ms_1ms_1}$) plants

	Chromosome number	Frequency
Number of seeds — 251		
Number germinated — 209		
Number twin seedlings — 6	40/40	5
	40/60	1
Abnormal seedlings — 15 (2 died before chromosome number determined)	40	4
	80	1
	~ 120	2
	~ 140	3
	~ 160	2
	~ 180	1

*Research supported in part by a grant from the American Soybean Association Research Foundation.

In addition to six pair of twin seedlings, we had 15 seedlings with visibly abnormal cotyledons and/or roots. The one tetraploid plant was probably the result of fertilization of a triploid ovule ($\underline{ms_1 ms_1 ms_1}$) by a haploid sperm ($\underline{Ms_1}$) from a sib plant. This is suggested because the tetraploid plant did not have failure of cytokinesis which characterizes $\underline{ms_1 ms_1}$ (diploid) and $\underline{ms_1 ms_1 ms_1 ms_1}$ (tetraploid) plants. It is also interesting that the chromosome numbers of the remaining seedlings are multiples of 20, not 40; i.e., multiples of the gametic, not the sporophytic chromosome number. The high ploidy levels are consistent with our histological observations (Palmer and Albertsen, unpublished) and are compatible with the results of Cutter and Bingham (1975).

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2) Trisomic linkage tests.*

We are using three primary trisomics, Tri A, Tri B, and Tri C, in attempts to locate genes on specific chromosomes and to associate chromosomes with their respective linkage groups.

The trisomics were used as female parents in crosses with the various genetic types listed in Table 1. Chromosome numbers were determined from F_1 seedlings. Segregation ratios were determined in the field for the F_2 progenies from disomic and trisomic plants. The crosses for trisomics A and B (♀) were:

$$w\ ep\ T\ \widehat{YK_2}\ fg_1\ Y_{11} / w\ ep\ T\ \widehat{YK_2}\ fg_1\ Y_{11} \times (♂)\ W\ Ep\ t\ \widehat{yk_2}\ Fg_1\ Y_{11} / W\ Ep\ t\ \widehat{yk_2}\ Fg_1\ y_{11}$$

*Research supported in part by a grant from the American Soybean Association Research Foundation.

and for trisomic C (♀) were:

$$W\,\widehat{YK}_2\,/\,W\,\widehat{YK}_2 \times (♂)\; w\,\widehat{yk}_2\,/\,w\,\widehat{yk}_2\,.$$

No evidence of trisomic inheritance of any of the tested mutants was obtained (Table 1), with the possible exception of trisomic A and flower color. The condition tested was the duplex *Www* and a 2:1 ratio is expected if the extra chromosome-carrying pollen is eliminated. We observed 2.12:1 (Table 1). A more definitive test will be made in summer 1976 using the simplex *WWw* condition. Additional mutants to be tested in summer 1976 will include dt_1, ln_1, rj_1, y_{12}, ms_1, and ms_2.

Table 1

Segregation ratios of F_2 disomic and trisomic progenies for various characters

Genotype	Number of plants	Ratio	Number of plants	Ratio
	Disomic A		Trisomic A	
$W_1- : w_1w_1$	108:29	3.72:1	165:78	2.12:1
$T- : t\ t$	111:26	4.27:1	189:54	3.50:1
$Ep- : ep\ ep$	101:29	3.48:1	97:30	3.23:1
$Fg_1- : fg_1fg_1$[a]	77:23	3.35:1	71:29	2.45:1
$\widehat{YK}_2- : \widehat{yk}_2\widehat{yk}_2$[b]	114:23	4.96:1	183:60	3.05:1
	Disomic B		Trisomic B	
$W_1- : w_1w_1$	180:62	2.90:1	623:203	3.07:1
$T- : t\ t$	824:278	2.96:1	621:205	3.03:1
$Ep- : ep\ ep$	244:90	2.71:1	298:97	3.07:1
$Fg_1- : fg_1fg_1$[a]	72:28	2.57:1	78:22	3.55:1
$\widehat{YK}_2- : \widehat{yk}_2\widehat{yk}_2$[b]	834:268	3.11:1	618:208	2.97:1
$Y_{11}Y_{11} : Y_{11}y_{11} : y_{11}y_{11}$	70:147:62	1.13:2.37:1	56:121:60	0.93:2.02:1
	Disomic C		Trisomic C	
$W_1- : w_1w_1$	425:154	2.76:1	401:113	3.55:1
$\widehat{YK}_2- : \widehat{yk}_2\widehat{yk}_2$[b]	593:170	3.49:1	482:136	3.54:1

[a]We wish to thank Dr. R. I. Buzzell, Agriculture Canada, Harrow, Ontario, for determining Fg_1 or fg_1 from our leaf samples.

[b]Genetic type T253 is chlorophyll deficient (*y*) and has a saddle pattern (k_2).

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3) Linkage studies with a chromosomal interchange.*

Two chromosomal interchanges have been reported in soybeans by Williams and Williams (1938) and Williams (1948). We have been using the chromosomal interchange reported in 1948, which came from a cross between Glycine soja (PI 101.404B) and G. max. We received seed in 1970 from R. L. Bernard (U.S. Regional Soybean Laboratory) of PI 101.404B x Clark[6] as L68-7944-2. We have identified homozygous normal chromosome (N/N), heterozygous chromosomal interchange (N/T), and homozygous chromosomal interchange lines (T/T). The homozygous interchange line has been used in crosses in an effort to locate genes on their respective chromosomes. Heterozygous interchange plants can be identified on the basis of about 50% pollen and ovule sterility. Homozygous normal chromosome and homozygous interchange lines have complete pollen and ovule fertility. The data in Table 1 give no indication of linkage of the interchange with w_1, t, dt_1, st_2, st_3, or st_4.

Table 1

Chromosome linkage studies with a chromosomal interchange (F_2 and F_3 data)

Cross	Two-way independent assortment test	Chi-square	Total progeny
1) T241H x Clark T/T	(N/N + T/T) / N/T vs W/w	0.1648	1079
St_2st_2ww x St_2St_2WW	(N/N + T/T) / N/T vs St_2/st_2	0.2252	
2) T242H x Clark T/T	(N/N + T/T) / N/T vs T/t	1.7662	1341
St_3st_3tt x St_3St_3TT	(N/N + T/T) / N/T vs St_3/st_3	0.8653	
3) T258H x Clark T/T	(N/N + T/T) / N/T vs T/t	0.0045	1576
St_4st_4tt x St_4St_4TT	(N/N + T/T) / N/T vs St_4/st_4	0.0135	
4) dt_1dt_1tt x Clark T/T	(N/N + T/T) / N/T vs T/t	0.4424	1088
Dt_1Dt_1TT	(N/N + T/T) / N/T vs Dt_1/dt_1	0.0013	

*Research supported in part by a grant from the American Soybean Association Research Foundation.

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4) Environmental influence on total pollen grains per flower from normal and sterile plants of the Urbana male sterile.*

In 1975 we reported the ratio of normal pollen grains to coenocytic pollen grains per anther locule of greenhouse grown plants from the original North Carolina line of the ms_1 mutant. The observed ratio was 2:1 rather than the expected 4:1 (Palmer and Albertsen, 1975). Cooper and Boerma (1975), working with the Urbana male sterile, and Palmer and Winger (1975), working with Ames, Harosoy, and Urbana male steriles, proposed that the gene(s) conditioning male sterility are located at the same locus as the ms_1 gene. We began evaluations of the effects of the ms_1 gene in these lines, particularly to determine the ratio of total normal pollen grains to coenocytic pollen grains. The data presented here is from the Urbana male sterile. Similar information on the original North Carolina ms_1, Ames, and Harosoy male steriles is not yet available.

Table 1 is a compilation of total pollen grain counts per flower from fertile plants and sterile plants of the Urbana male sterile grown in the indicated environments. Total mean pollen counts were obtained from counting the pollen grains in each anther of a given flower separately and then adding the 10 anther totals to get the flower total. Five flowers were sampled for each normal flower entry and each sterile flower entry in Table 1.

We found variation in total pollen grains per flower in normal plants and sterile plants of the Urbana male sterile, depending upon environment. Consequently, the ratio of total normal pollen grains per flower to total coenocytic pollen grains per flower also varied (see Table 1). Other authors have reported pollen grain number variations in the same plant species. Swen (1935) reported that in soybeans there is variation in pollen grain number

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Table 1

Pollen counts of fertile and sterile plants of the Urbana male sterile grown in three environments

Location	Total pollen counts/flower[a]		Observed ratio	Expected χ^2 4:1
	Normal	Sterile		
Field: Ames, IA (August, 1975)	5147.0 ± 176.8	1086.8 ± 44.5	4.74:1	25.65**
Greenhouse: Ames, IA (September, 1975)	3737.8 ± 228.3	1176.0 ± 29.5	3.18:1	47.50**
Field: Athens, GA[b] (July, 1975)	4877.8 ± 290.0	1305.4 ± 37.8	3.74.1	4.78*

*Significant at 5% level.

**Significant at 1% level.

[a]Given as mean ± standard error of the mean.

[b]We wish to thank Dr. H. R. Boerma, University of Georgia, Athens, for collecting the flowers.

depending upon variety. His total pollen grain counts ranged from 1870 pollen grains per flower to 5010 pollen grains per flower among the 5 varieties he tested. Similarly, Beri and Anand (1971) reported that the number of pollen grains per anther in wheat varied from 581 to 2158 among various varieties.

Our preliminary data have suggested that the final ratio of normal pollen grains to coenocytic pollen grains cannot be singly characterized for the $\underline{ms_1}$ gene in the Urbana male sterile. Environmental influences were significant in modifying the total number of pollen grains produced per flower.

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1) Soybean dwarf virus disease.

In the cultivation of soybean plants in Hokkaido and in the Tohoku region of Japan, the most difficult problem at present is soybean dwarf virus disease (SDV). This disease was first found on the soybean variety 'Tsurunoko' in southern areas of Hokkaido in about 1952. Since then researchers have been attempting to overcome it, and some aspects of this disease were clarified: for example, this disease was not transmitted by manual inoculation of sap or through seeds, but was transmitted by the grafting method or foxglove aphid in a persistent manner. Two strains of SDV were obtained from naturally infected soybean plants. On the basis of their symptoms, one of them was designated a dwarfing strain, which caused a dwarfing of plants. The other was designated a yellowing strain, which caused a slight chlorosis of leaflets.

Recently, SDV has been gradually increasing throughout Hokkaido and the Tohoku region; it has been found that the disease occurs in all varieties of soybean, although different soybean varieties infected with SDV in the field show different symptoms and different degrees of damage. For example, the soybean variety 'Yuuzuru', which is one of the commercial varieties grown in the central areas of Hokkaido, showed that an average of 42.7% of plants were infected between 1970 and 1975. With the 'Adams' variety of soybean, however, the percentage of plants infected was only 3.1; if the Adams variety of soybean was inoculated by the foxglove aphid in a persistent manner, all the plants became infected. The extent of yield reduction was closely related to the percentage of infected plants. For example, when 50% of plants in the

field were infected, the yield of the plants dropped by about 40%.

Since 1966, about 2300 soybean varieties have been collected from many places to find a variety resistant to SDV. However, a soybean variety having a true resistance has not been found, although some varieties having a relatively high resistance, such as Adams, were found. So since 1972, soybean varieties such as Adams have been used as artificial crossing material to breed a recommended variety with a field resistance to SDV. On the other hand, it is necessary that as many varieties should be collected from as many parts of the world as possible and tested to find a variety truly resistant to SDV.

We would appreciate your kind cooperation and advice.

Rate of soybean plants infected with SDV in the field in 1975

Variety name	Number of plants	Number of infected plants	% infected
Shiro-tsurunoko	389	291	74.8
Oshima-shirome	481	90	18.7
Koganejiro	528	179	33.9
Ouhouju	504	41	8.1
Medium green	467	33	7.1
Adams	474	7	1.5
Bavender special	501	40	8.0
Yuuzuru	472	310	65.7

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1) Evaluation of commercial soybean cultivars for leaf feeding resistance to *Heliothis zea*.*

The phenomenon of plant resistance to insects may be classified into three components, namely, nonpreference, antibiosis, and tolerance (Painter, 1951). Clark *et al*. (1972) observed that although PI 227.687 had many *Heliothis zea* eggs and larvae on the plants, the amount of pod damage was considerably less as compared with PI 171.451 and PI 229.358. They suggested that PI 227.687 might have some antibiosis mechanism against *H. zea*. Leaf feeding studies have shown that these PI's have high level of antibiosis for *H. zea* (Hatchet, Beland and Hartwig, 1974) and Mexican bean bettle (*Epilachna varivestis*—Mulsant) (Van Duyn, Turnipseed and Maxwell, 1972).

The objective of this study was to investigate leaf feeding resistance to *H. zea* by means of antibiosis tests, among soybean cultivars commonly grown in the Middle Atlantic States of the U.S.A.

Materials and methods: Seven commercial soybean cultivars ('Cutler,' 'Essex,' 'Hill,' 'York,' 'Delmar,' 'Wye' and 'Shore'), 3 plant introductions (171.451, 229.358 and 227.687) and one advance breeding line (D67-3297) were evaluated for antibiosis in foliage feeding tests. The cultivars were planted in the field on May 25, 1974, to provide fresh leaves for feeding tests. On August 1, 1974, a leaflet was selected from the uppermost fully developed trifoliolate of each cultivar and placed in clear plastic containers 5.1 cm in diameter and 3.7 cm deep. Each cup contained two paper towel discs of 1.27 cm diameter soaked in water to maintain humidity in the cup. *H. zea* larvae were reared for 6 days on the general lepidopterous diet in 1 oz clear jelly cups. On the seventh day 30 *H. zea* larvae of uniform size were selected for each soybean cultivar. A single larva was placed in each cup and covered. Foliage was replaced at 24 hr intervals throughout the larval period.

Larval mortality was recorded every day, and the weight of survivors was recorded after 6 days feeding on leaves. Pupal weight on the ninth day after pupation and the number of days to pupation and adult emergence were also recorded.

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Table 1

Development of *Heliothis zea* larvae on leaves of different soybean cultivars or PI's

Cultivar or PI†	Larval wt. (mg)††	No. larvae pupated	$\bar{x}$ days to pupation	Pupal wt. (mg)†††	$\bar{x}$ days in pupal stage	No. adults emerged	% emergence
D67-3297	366a*	19	17.7d*	245a*	12.9a*	15	50.0
Cutler	360a	15	19.4bcd	211abcde	11.9b	8	26.7
Delmar	347a	20	18.8cd	228ab	11.9b	7	23.3
Hill	319ab	14	18.7cd	229abc	11.8ab	6	20.0
Essex	310ab	15	19.2bcd	190bcde	11.0b	8	26.7
York	300ab	14	19.3bcd	208abcde	11.7b	7	23.3
Wye	254bc	12	20.3abc	232abcd	11.7b	10	33.3
Shore	244bc	12	21.1ab	166de	10.8b	5	16.7
PI 171.451	222c	9	20.8abc	168cde	11.5b	4	13.3
PI 229.358	207c	10	21.8a	176bcde	10.7b	6	20.0
PI 227.687	189c	12	21.8a	162e	11.7b	7	23.3

*Means not followed by the same letter were significantly different at the 0.05 probability level according to Duncan's multiple range test.

†30 larvae/treatment.

††Mean weight of larvae after 6 days feeding.

†††Mean weight of pupae on ninth day after pupation.

Results and discussion: H. zea showed a marked differential response in larval and pupal weights, mean days to pupation and percentage emergence when reared on leaves of different soybean cultivars (Table 1). The larvae reared on D67-3297 gained maximum average larval (366 mg) and pupal (245 mg) weights within the period of experimentation. Percentage emergence of moths was also the highest (50%) for this cultivar. The results indicated that D67-3297 was the most susceptible and had the lowest level of antibiosis. The least larval (189 mg) and pupal (162 mg) weights were recorded on PI 227.687. Percentage emergence of moths was 13.3% for PI 171.451 and 16.7% for Shore, indicating a high level of antibiosis for these two cultivars.

Larvae reared on the leaves of Shore, Wye and the three PI's gained significantly less weight as compared with York, Essex, Hill, Delmar, Cutler and D67-3297. Significant differences were also found in pupal weight (Table 1). Pupal weights of H. zea reared on Shore, Essex, and the three PI's were significantly less than Wye, York, Hill, Delmar, Cutler, and D67-3297.

H. zea larvae reared on Shore, Wye and the three PI's passed through a significantly extended larval stage as compared with York, Essex, Hill, Delmar, Cutler and D67-3297.

Cultivars Shore and Wye exhibited a high level of antibiosis for H. zea and show promise in reducing the amount of pod damage, overwintering pupal population and number of moths in the next generation. Planting of soybean cultivars with high level of antibiosis will also reduce the number of insecticide applications.

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1) Seed yield efficiency in soybeans.

Soybean (*Glycine max* (L.) Merrill) cultivars with high seed yield efficiency (SYE) can be used in breeding programs to increase yield. An efficient cultivar can be characterized either by a high ratio of seed to nonseed dry weight (above ground unthreshed air-dry weight of plant at maturity minus seed weight) or by a steep regression slope of seed over nonseed dry weight. High SYE indicates that a high proportion of total plant dry weight is seed weight (Veatch, 1930). Dry bean (*Phaseolus vulgaris*) cultivars studied by Wallace and Munger (1966) differed distinctly in their harvest indices (HI = economic yield divided by total plant dry weight x 100). Efficient plants utilize more energy for production of seed and less for nonseed plant parts. Schutz and Brim (1967), utilizing regression coefficient analysis of SYE values, found that certain varieties became more efficient in competitive situations than in pure stands.

The present investigation was undertaken to determine the extent of variability of SYE in ten selected soybean varieties.

Materials and methods: The experiment was conducted during 1971 at the Agronomy Farm of The Ohio State University, Columbus, Ohio. Ten soybean varieties, belonging to maturity groups I, II, III, and IV, were selected on the basis of their diversity in maturity, plant height, and growth habit. Most of the seeds were supplied by the Regional Soybean Laboratory, Urbana, Illinois. The seedlings grown in the greenhouse were randomly arranged in the field and spaced 91 cm apart in 71 cm rows. The number of single plant replications were: 'Aoda,' 12; 'Cayuga,' 9; 'Giant Green,' 8; 'Habaro,' 20; 'Hakote,' 9; 'Henry,' 46; 'Kent,' 39; 'Kura,' 13; 'Manchuria,' 7; and 'Wayne,'

45. Each plant was harvested at maturity at ground level, bagged separately in a cloth bag, and analyzed separately. Chow's test (1960) was used to test the significant difference between regression coefficients of different cultivars. The unthreshed weight of the plant included the air-dry weight of main stem, branches, pods and all seeds; and nonseed dry weight was calculated by subtracting seed yield from this weight. Seed yield to nonseed dry weight ratio or seed yield efficiency (SYE) was calculated by dividing seed yield by nonseed dry weight of the plant.

Results and discussion: Results showed a marked variation in SYE as expressed by ratio of seed yield to nonseed dry weight among the cultivars within each maturity group and between different maturity groups (Table 1). Wayne was the most efficient cultivar with SYE of 1.52. Cayuga ranked second with SYE of 1.51 and Manchuria was a close third at 1.49. Aoda and Giant Green were least efficient and SYE for these varieties was 1.28. This suggests that of the total energy required in producing a Wayne plant, more is utilized in production of seed, while Aoda and Giant Green utilize a larger proportion of their energy in production of nonseed dry weight and consequently produce less seed. The mean yield, nonseed dry weight and SYE (Table 1) for Kent indicated that it was the highest yielding but with mediocre SYE of 1.42. In contrast, Cayuga produced only 14.1 g seed and 9.3 g nonseed dry weight but the mean SYE was very high (1.51). These data suggest that the high yielding cultivars under cultivation today may not be the most efficient varieties from the point of view of water and energy utilization.

The statistical analysis of regression coefficients of seed yield with nonseed dry weight, which was another measure of efficiency, also revealed that considerable variability existed among the ten cultivars. Hakote ($Y = 2.503 - 13.413$) was the most efficient cultivar in producing seed yield per unit of nonseed dry weight, and Henry ($Y = 1.113X + 4.229$) was the least efficient but these two varieties were not the most and least efficient respectively as indicated by the ratio (SYE) of seed to nonseed dry weight. Perfect agreement of these two tests should not be expected because mathematically different parameters were being measured by the use of ratios and regression coefficients.

SYE is important to both farmers and researchers in its effect on water and fertilizer usage.

Table 1

Mean values per plant for different traits in 10 soybean cultivars

Cultivar	Nonseed dry wt. (g)	Seed yield (g)	SYE (ratio)	Slope	Intercept
Cayuga	9.3	14.1	1.51	1.629	- 1.022
Giant Green	9.8	13.0	1.28	2.158	- 8.214
Habaro	13.1	19.7	1.44	1.682	- 2.436
Manchuria	9.1	14.8	1.49	1.960	- 2.978
Hakote	12.8	19.0	1.44	2.503	-13.413
Henry	21.4	28.0	1.32	1.113	4.229
Kura	18.4	24.7	1.35	1.125	3.935
Wayne	30.8	47.6	1.52	1.626	- 3.075
Aoda	20.6	27.2	1.28	1.455	- 2.840
Kent	40.2	59.0	1.42	1.626	- 6.314

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1) <u>Heat injury tests as a screening tool for heat tolerance in soybeans</u>.

One of the objectives of the soybean physiology-breeding program at Nebraska is the evaluation of various procedures used for measuring the response of soybeans to heat and drought stress. We are primarily interested in techniques amenable to large-scale screening of soybean populations or germplasm, so that heat or drought tolerant genotypes can be identified and used in our breeding program. Consequently, the important considerations are rapidity in sampling, simplicity in equipment and procedural requirements, and detection of genotypic (rather than environmental) differences.

One technique that we are currently evaluating appears to hold some promise as a screening tool. This technique has been used successfully in the evaluation of sorghum cultivars for heat and drought tolerance (Sullivan, 1972). The technique is based on the observation that when leaf tissue is injured by high temperatures or low humidities, electrolytes diffuse out of the injured cells. If this tissue is bathed in deionized water, the amount of electrolyte "leakage" (which is dependent upon the degree of induced injury) can be determined by measuring the electrical conductivity of the water. Sullivan (1971) has observed that the results of this test agree very well with the heat or dessication tolerance of the intact sorghum plant. Injury can be induced by either elevated temperatures or specific low relative humidities (to produce dessication). However, dessication injury tests are more time-consuming, tedious, and sometimes difficult to control when compared with heat injury tests.

The technique we have used on soybeans is essentially identical to that described by Sullivan (1972), except that injury is induced by a 15-min incubation in a thermostatted water bath at about 50 C. Since the injury versus temperature curve is sigmoid, the sensitivity of the technique is greatest at temperatures inducing about 50% injury. We have found that on the average a 15-min incubation at 50 C will usually result in about 50% injury, but slight adjustments (± 1 C) in the incubation temperature during the growing season may be necessary to compensate for the acclimatization or "hardening" of soybean

plants that occurs as the summer progresses.

During the summer of 1975, we used the heat injury test to evaluate the heat tolerance of 15 varieties and 10 advanced selections. Each of these 25 strains were replicated four times in 4-row, 20-foot plots. Moisture stress during and after planting (May 13) resulted in poor germination and subsequent uneven and reduced stands. Normal temperatures and rainfall occurred during June, but with the exception of some rainfall on July 19, hot and dry weather conditions prevailed throughout July, August, and September. Heat injury determinations were performed on each plot at three different dates (July 7, July 24, and Aug. 6). Heat injury data for the 15 varieties are shown below:

Entry	% heat injury (avg. 3 dates)*	Entry	% heat injury (avg. 3 dates)*
Corsoy	36.7	Wayne	53.9
Harcor	39.5	Hark	54.2
Pomona	43.1	Clark 63	54.8
Calland	46.4	Kent	55.8
Woodworth	47.4	Cutler 71	57.7
Wells	50.1	Beeson	59.1
Williams	51.6	Bonus	63.6
Amsoy 71	52.8		

*L.S.D. (0.05) = 7.5.

Highly significant varietal differences in heat injury were observed on each sampling date and on the combined average across sampling dates. These varietal differences in heat injury were, for the most part, relatively consistent over sampling dates. The variety 'Bonus,' for example, ranked highest in heat injury on the last two sampling dates and second highest on the first sampling date. Similarly, 'Beeson' consistently ranked high in heat injury on each sampling date. At the other end of the spectrum, 'Corsoy' and 'Harcor' consistently ranked low in heat injury. It is interesting to note that Corsoy and Harcor possess leaves that are darker green, somewhat smaller,

and more fibrous than those of Bonus and Beeson. Very low yields were obtained from this trial due to the reduced stands mentioned earlier and to the protracted drought occurring from mid-season on. Generally the early-maturing varieties yielded more than the late-maturing varieties. Correlations of yield with heat injury were negative as expected. However, only the correlation for the third sampling date was significant. Correlations of heat injury with maturity were nonsignificant.

We are continuing our investigations of this technique to determine if heat injury is a reliable indication of heat tolerance. Some morphological characteristics related to the degree of heat injury are also being studied.

References

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2) Stomatal frequency and heat and drought stress in soybeans.

Stomata are the primary anatomical structures involved in water loss and gas exchange in plants. Genetic differences in stomatal frequency may have potential in breeding for increased photosynthetic or water-use efficiency. Miskin and Rasmusson (1970), for example , found that barley lines with low stomatal frequencies transpired less water than lines with high stomatal frequencies, with no observed difference in the rates of photosynthesis. In another study, Ciha and Brun (1975) reported differences in stomatal frequencies among soybean varieties and suggested the possibility of genetically controlling water loss without affecting photosynthesis by reducing stomatal frequency. These authors expressed stomatal frequency as the number of stomata per square mm of leaf.

In 1974, a study was conducted to determine differences in stomatal frequency among soybean varieties. The relationship of stomatal frequency

to heat and drought tolerance was also investigated. Six genotypes, three heat tolerant and three intolerant, as measured by a temperature-mediated leaf injury technique (Sullivan, 1972), were grown as part of a heat and drought tolerance study involving 24 strains and varieties. Each genotype was replicated four times in 20-foot, 4-row plots in a split-plot arrangement with irrigated and nonirrigated conditions representing the whole plots.

Five plants per plot, selected at random, were sampled for each of the six genotypes. The acrylic imprint method of Brown and Rosenberg (1970) was used to determine stomatal frequency. Acrylic imprints were made on a portion of the abaxial side of the terminal leaflet of the top, fully expanded trifoliolate leaf, at a point midway between the base and the tip. The imprints were lifted from the leaf with cellophane (Scotch 600) tape and attached to microscope slides. The slides were placed under a microscope equipped with a model "T" type camera from which the lens had been removed, so that the image was projected onto the camera back (normally covered by film). Thus, the camera back served as a screen for the enlarged image, allowing the stomata and epidermal cells to be counted without eyestrain or photography. Stomatal frequency for each genotype was expressed as a stomatal index: $I = [(\text{stomata})/(\text{stomata} + \text{epidermal cells})]\,100$. This formulation, first suggested by Salisbury (1927), expresses stomatal frequency as a ratio of stomata to the total number of epidermal cells, and eliminates the effects of epidermal cell size that could influence stomatal frequency measurements based on number per unit area.

The results (Table 1) show highly significant differences in the stomatal indexes among the six genotypes observed. Differences in stomatal indexes for varieties under different water treatments were not significant. Stomatal index showed no correlation to heat tolerance under nonirrigated conditions, but under irrigation, heat tolerant genotypes tended to have a lower stomatal index.

References

Brown, K. W. and N. J. Rosenberg. 1970. Influence of leaf age, illumination, and upper and lower surface differences on stomatal resistance of sugar beet (*Beta vulgaris*) leaves. Agron. J. 62: 20-24.

Ciha, A. J. and W. A. Brun. 1975. Stomatal size and frequency in soybeans. Crop Sci. 15: 309-312.

Table 1

Stomatal indexes of six soybean genotypes

	Stomatal index						
Genotype	Irrigated	Nonirrigated	$\overline{x}$				
Hark	10.99	10.36	10.68	a*			
Chippewa 64	8.94	10.84	9.87	a	b		
Beeson	9.97	9.18	9.57	a	b	c	
A66-1746-9	8.22	10.53	9.38	a	b	c	d
Bonus	9.42	8.13	8.78		b	c	d
L66-1359	8.33	6.92	7.63				d
Means	9.31	9.33	9.32				

*Values followed by the same letter are not significantly different at the .05 level.

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1) Multiple resistance to insects.

Soybean lines PI 229.358, PI 171.451 and PI 227.687 were reported to be resistant to Mexican bean beetle (*Epilachna varivestis*) (Van Duyn, Turnipseed

and Maxwell, 1971). Their study was based on forced feeding tests conducted in the laboratory and by field observations. The line PI 229.358 has been intensively used by soybean breeders for incorporating resistance into commercial germplasm. It was suspected that these lines may carry resistance to other insects feeding on soybeans. In the present study, PI 229.358 was evaluated against 'Lee 74,' a susceptible line, for leaf feeding by larvae of the corn ear worm (Heliothis zea), army worm (Spodoptera exigua) and soybean looper (Pseudoplusia includens). The method used was basically that suggested by Barnes and Ratcliffe (1967). Three fully developed leaflets of each line were stapled alternately in a circular pattern on a sheet of paper. The paper was kept on moist pads in a large plastic box. For each insect, three small larvae were released in the box and kept overnight. The leaf areas eaten by the larvae were determined for both Lee 74 and PI 229.358. The results indicated that PI 229.358 carried resistance to all three insects under study.

Screening large population: In segregating populations, large numbers of lines need to be screened. The method described above employs a large box for each sample. It would be desirable if one could cut a small disc from a leaf and screen the material in a small container, thus allowing a large number of lines to be screened. This was attempted using two 1.5 cm x 1.5 cm cut leaf discs of PI 229.358 and Lee 74 in a 10 cm petri plate. A small amount of wet tissue paper on the bottom of the plate retarded drying of the leaves. One larva of the corn ear worm was released in each plate and scored the following day. No definite feeding pattern was observed after many tests were run with PI 229.358 and Lee 74. These results indicate that feeding trials using a small cut leaf disc in a petri plate are inadequate for screening purposes against the corn ear worm. Thus, material may be tested using larger containers and entire leaflets or some other method must be developed for handling large populations using small leaf samples.

References

Barnes, D. K. and R. H. Ratcliffe. 1967. Leaf disc method of testing alfalfa plants for resistance to feeding by adult alfalfa weevils. J. Econ. Entomol. 60: 1561-1565.

Van Duyn, J. W., S. G. Turnipseed and J. D. Maxwell. 1971. Resistance in soybeans to the Mexican bean beetle: I. Source of resistance. Crop Sci. 11: 572-573.

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1) Cotyledon culture.

A procedure for aseptically culturing immature soybean cotyledons has been developed to study the synthesis of seed storage proteins. Experiments were carried out so that one cotyledon from an embryo was compared to the second cotyledon. Cotyledons were normally incubated for 6 days at 25 C in light with gentle shaking. The medium was modified from Linsmaier and Skoog (1965) by omitting any auxin and by replacing NH_4NO_3 and KNO_3 with glutamine (30-120 mM).

Under these conditions, cotyledons grew better than on the plant and produced more protein. Both major groups of storage proteins (7S and 11S) increased throughout the culture period. The relative amount of these two storage proteins was similar to that of cotyledons developed on the plant.

Using this culture method in pulse-chase experiments with tritiated glycine, the turnover of storage proteins was found to be very slow while the half life of the nonstorage proteins was 1 to 2 weeks.

Reference

Linsmaier, E. M. and F. Skoog. 1965. Organic growth factor requirements of tobacco tissue cultures. Physiol. Plant. 18: 100-127.

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1) Progress in obtaining soybean haploids 2n = 20.

Male sterility gene ms_1 from North Carolina was transferred to maturity groups I, II, and III over the last few years to facilitate the use in Wisconsin of the twinning and haploidy phenomena associated with ms_1ms_1 plants. In 1975 we had an extended fall growing season and seed was obtained from several hundred male sterile ms_1ms_1 plants, representing maturity groups I, II, III,

IV, and V. Honey bees were used as pollinators. Seed set was lowest for Group I (1-2 seeds/plant) and highest in Group V (20-60 seeds/plant). It is not known whether seed set was affected simply by less bee pollination of the earlier flowering steriles or by greater female sterility in the early background.

About 8000 seeds have been screened for twins and haploids. The frequency of twinning is about 2% and the frequency of twin sets containing a haploid member is about 2%. Thus far, four viable haploids $2\underline{n} = 20$ have been isolated. We are still screening at this writing and these figures may change slightly in the final analysis.

The intended use of the haploids is in production of aneuploids, particularly deficiency aneuploids. Two major unknowns at the moment are: (1) whether or not $\underline{ms_1}$ haploids will produce deficiency gametes (they may produce only numerically unreduced gametes), and (2) whether or not deficiency gametes and aneuploids will be viable. Viability or lack of it will provide a test of the hypothesis that the cultivated soybean $2\underline{n} = 40$ is a tetraploid.

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G. L. Cutter

2) Histology of the embryo sac of male sterile $\underline{ms_1 ms_1}$ soybeans.

The fact that $\underline{ms_1 ms_1}$ plants in maturity ranges I to V were producing haploids, triploids, and even higher ploidy levels along with the predominant normal diploids, indicated the female gametophyte was at least occasionally functioning abnormally. Histological sections of 92 male sterile pistils from plants about Groups III and IV, indicated only about 28% of the ovules had a normal embryo sac, by our interpretation. The remainder most commonly had extra nuclei in the regions of the secondary nucleus (endosperm mother cell) and/or the egg apparatus. The haploids may occur as twin members when one of these extra nuclei develops parthenogenetically. The polyploids may be the result of $2\underline{n}$, $3\underline{n}$, etc., gametes being formed by fusion of the extra nuclei, followed by union of these female gametes with reduced or unreduced male gametes.

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E. T. Bingham

V. INDEX OF CONTRIBUTORS

VI. GENETIC STOCKS AVAILABLE

Procedure for Requesting Seeds from the USDA Soybean Germplasm Collection

The USDA maintains a collection of soybean germplasm comprising about 5,000 strains of current and obsolete American varieties, foreign introductions, genetic types, and related species. Seed packets are available for research purposes upon request. The following points are listed to guide you in requesting seeds:

1) Please address requests for early-maturing varieties and PI and FC strains (Maturity Groups 00 to IV), Genetic Types (T-strains), and wild species of *Glycine* to:

   Dr. Richard L. Bernard
   U.S. Regional Soybean Laboratory
   160 Davenport Hall
   Urbana, IL 61801
   Tel. 217/333-4639 (FTS 958-9124)

   and requests for late-maturing varieties and PI and FC strains (Groups V to X) to:

   Dr. E. E. Hartwig
   Delta Branch Experiment Station
   Stoneville, MS 38776
   Tel. 601/686-9311, Ext. 230

   and requests for the Cytological Collection which includes translocations, trisomics, tetraploids, etc., to:

   Dr. R. G. Palmer
   Agronomy Department
   Iowa State University
   Ames, IA 50011
   Tel. 515/294-5076 (FTS 865-8372)

2) Time of requests:
   Requests will be filled as soon as possible after receipt, but large requests may take a month or so to packet.

3) Quantity of seeds:
   a) A standard request is about 50 seeds per packet, but we can easily furnish a smaller number and, if seed supply permits, will also furnish larger amounts. Specify how many you want. If no

amount is specified, we will send 50 seeds.

b) Seed counts are only approximate, as we usually cup the seeds, and only partially compensate for size and germination variation.

c) In the case of named varieties we can sometimes furnish larger amounts, up to a kilogram or so, especially in the case of varieties which we are currently yield testing.

d) The tropical perennial species (all species other than _G. max_ and _G. soja_) are difficult to grow and reproduce, and normally only a few (5 to 10) seeds will be sent.

e) A seed packet (30 seeds) of trisomics A, B, and C will be made available for research purposes. The seed supply of several of the tetraploids is limited and only a few (5-10) seeds will be available. These can be ordered from Ames.

4) The following lists and reports are available to assist you in selecting and requesting germplasm. Those marked * are available from Stoneville, the others from Urbana.

a) Checklists giving name and maturity group. Extra copies are available to use in making requests for large numbers of strains.

1) Groups 00 to IV varieties, 1976.
2) Groups 00 to IV FC and PI strains, 1975.
*3) Groups V to VIII varieties and FC and PI strains, 1975.

b) Evaluation reports giving origin of strains and descriptive, agronomic, and seed composition data:

1) Varieties, Groups 00 to IV, 1970.
2) Varieties, and FC and PI strains, Groups 00-0, 1965.
3) Varieties, and FC and PI strains, Groups I-II, 1966.
4) Varieties, and FC and PI strains, Groups III-IV, 1969.
*5) Varieties, and FC and PI strains, Groups V-X, 1975.
6) Recent varieties and PI additions, Groups 00-IV, 1970.

c) List of Genetic Type Collection, 1976.

d) List of backcross isolines of Clark and Harosoy.

e) List of wild soybeans, *Glycine soja*, 1976.

f) List of perennial *Glycine* accessions.

5) Before sending in your request, please verify the accuracy of your strain designations and whether they are maintained at Urbana or Stoneville by checking them against a current checklist or evaluation report. We get many requests for nonexistent varieties and PI's and you are in a better position than we are to correctly identify what you want.

6) There is no charge for seed for research purposes.

7) We appreciate knowing the intended use of the seeds in all cases, and we must know it in the case of very large requests. We also appreciate receiving copies of publications or other information that you derive from the use of these seeds.

March, 1976

Table 1

Soybean Genetic Type Collection List†

Strain*	Genes or description**	Source***	Maturity	Code††
T16	brown hilum on black seed	Found in 'Ebony' before 1930	IV	WTNTn SBlBr
T31	p_2	Found in Soysota x Ogemaw, from F. W. Wentz, Ames, Iowa, in 1926	IV	P-PtBr SRbrRbr
T41	$ln(d_1 d_2)$	Unknown	IV	WTNBr SGnG-Bl
T43	P_1(cyt-G)	Progeny 435B from Medium Green x "glabrous", before 1927	V	W-GBr DGnBr
T48	spread hilum	From Manchu x Ebony before 1930	IV	WTNBr SYBl
T54	dt_1	Found in 'Manchu' before 1927	III	PTNBr SYBr
T69	T td cyt-G	Pure line of PI 64.698	IV	WGNBl SBlBl

†For additional information see Section VI Genetic Stocks Available, Soybean Genetics Newsletters Volumes 1 and 2, and ASA Monograph No. 16, Chapter 4, "Qualitative Genetics," by R. L. Bernard and M. G. Weiss. American Society of Agronomy, Madison, Wisconsin.

††Descriptive Code Sequence: 1234 567 (underlined letters used in code).

1—Flower Color: Purple, White, Magenta, or Light purple

2—Pubescence Color: Tawny, Light tawny, or Gray

3—Pubescence Type: Normal, Sparse, Appressed, Curly, Glabrous, Irregular, Puberulent, or Semi-appressed (Sa Sp means that pubescence is both semi-appressed and sparse)

4—Pod Color: Black, Brown, or Tan

5—Seed Coat Luster: Dull, Shiny, Intermediate, or Bloom

6—Seed Coat Color: Yellow, Green, Gray, Black, Brown, Reddish brown, Imperfect black, or Buff (may have prefix Light or Dark)

7—Hilum Color: Same abbreviations as seed coat color.

*For T-strains with an H suffix (e.g., T211H) the gene is carried as the heterozygote because the homozygous mutant is lethal, sterile, or very weak.

**Secondary traits are in parentheses.

***Selections were made at Urbana unless otherwise indicated. Numerical superscripts are used to indicate backcrosses; e.g., $Lincoln^2$ x Richland means Lincoln x (Lincoln x Richland).

Strain*	Genes or description**	Source***	Maturity	Code[††]
T85	brown flecks on black seed	Pure line of PI 47.131	II	PTNBr SBlBl
T93	$v_1(D_1d_2$ or $d_1D_2)$	Found in a hybrid population before 1931	I	PTNBr SGnBl
T93A	$v_1(d_1d_2)$	From T93	II	WTNBl DGnG
T102	y_4	Found in 'Wilson-5' before 1932	III	PGNTn SBlBl
T104	d_1d_2 G cyt-G	From T42 (green cotyledon from H. Terao) x 'Chromium green' before 1932	IV	PTNBr SGnBl
T109	ln G r^m se td	Pure line of PI 84.631	III	WGNBr SGnGn
T116	y_5	Found in radium-treated PI 65.388 before 1934	III	PTABr SBrBr
T117	$Dt_2lw_1Lw_2$	From AK114 x PI 65.394. L34-602	IV	PGNBr DYIb
T122	$lo(d_1d_2)$	Unknown, before 1934	IV	WGNTn DBfBf
T125	r^m	Pure line of PI 91.073	IV	PTNBr SBrBr
T134	chlorophyll deficient $(=y_5?)$	Found in Illini x Peking in 1937	III	WGNBr SYBf
T135	y_9	Found in 'Illini' in 1938	III	WGNBr SYBf
T136	$y_6(ln\ dt_1)$	From PI 88.351 x Rokusun in 1937	IV	WGNBr DYBf
T138	y_7y_8	Unknown. L35-1156	IV	PTNBr SYBl
T139	g y_3	Found in 'Illini' by Brunson in Kansas about 1936	III	WGNBr SYBf
T141	pc	Pure line of PI 84.987	III	P-CTn DYBf
T143	Lf_1 g y_3	From T138 x T137 (T137 is y_3 from a cross in PI 81.029)	III	WTNBr SBlBl
T144	$d_1d_2v_1\ y_7y_8$	From LX431: T93A x T138	IV	PTNBr SGnBl
T145	P_1	Unknown	III	W-GTn SBrBr
T146	r^m	From LX286: PI 82.235 x T125	IV	PTNBr DBrBr
T152	i	Mutant in 'Lincoln'	III	WTNBr SBlBl

Strain*	Genes or description**	Source***	Maturity	Code††
T153	k	Mutant in 'Lincoln'	III	WTNBr SYBl
T157	i	Mutant in 'Richland'	III	PGNBr DIbIb
T160	chlorophyll deficient	Found in 'Hahto (Michigan)'	IV	PTNTn SGnBr
T161	y_{10}	Found in L36-5 from Mandarin x Mansoy in 1940	IV	WTNBr SYBl
T162	y_{17}	Found in 'Mandarin' in 1940	I	PGNBr SYY
T164	slightly variegated(?)	Found in 'Morse' in 1941	IV	WGNBr SGnGn
T171	long peduncle	Unknown	IV	WTNBr SYG-Bl
T173	f(ln)	From Keitomame (f) x PI 88.351 (ln)	IV	WGNTn SYY
T175	$E_1t(dt_1)$	Unknown	IV	WGNTn DBfBf
T176	lw_1 lw_2	Unknown	II	PGNBr SYIb
T180	Rj_1	From same F_3 plant as T181. L46-1741-2	IV	WTNBr DYBl
T181	rj_1	Found in Lincoln^2 x Richland. L46-1743-2	IV	WTNBr DYBl
T201	rj_1	From L46-1743 x L46-1741	IV	WTNBr SYG
T202	Rj_1	Sib of T201	IV	WTNBr SYG
T203	fe	Pure line of PI 54.619	II	WGNBr SYBf
T204	ln lo	From T136 x T122. L48-101	IV	WGNTn DBfBf
T205	lw_1lw_2	From Dunfield x Manchuria 13177. L48-163	IV	PGNBr SYIb
T207	$Pd(dt_1Dt_2)$	Pure line of PI 80.837	IV	PGDnBr SYY
T208	Se, small seeds	Pure line of PI 196.176	IV	PGNTn DYBf
T209	dwarf	From Lincoln x "wild dwarf". L50-155	IV	PTNBr SGG-Bl
T210	df_2	Found in colchicine-treated 'Lincoln'. L49-738	IV	WTNBr SYBl
T211H	pm	From Kingwa x T161 at Lafayette, Indiana CX3941-844-2-5	IV	WLtNBr SGnBl

Strain*	Genes or description**	Source***	Maturity	Code[††]
(T212, T213, T214 tetraploids, transferred to Cytological Collection)				
T215	L_1l_2 (small seeds)	Pure line of PI 85.505	IV	PGNBl DYY
T216	reddish black seeds	From PI 86.038 x PI 88.351. L46-266	IV	WGNBr SRblRbl
T217	defective seed coat	Pure line of PI 196.166	IV	PTIrBr SBlBl
T218	chlorophyll chimera	Found in 'Illini' in 1952 (leaf resembles T225)	III	WGNBr SYBf
T219H	y_{11}	Found in Richland x Linman 533 in 1941 at Ames, Iowa. A691-1	III	PTNBr DYG
T220	chlorophyll deficient	Found in 'Lincoln'. L46-431	III	WTNBr SYBl
T221	chlorophyll deficient	Found in 'Peking'. L46-426	IV	WTNTn SBlBl
T223	chlorophyll deficient	Found in 'Richland'. L46-429	II	PGNBr DYG
T224	chlorophyll deficient	Found in 'Richland'. L46-428	II	PGNBr DYG
T225	Y^m_{18}	Found in 'Lincoln' in Iowa	III	WTNBr SYBl
T225H	$Y_{18}y_{18}$	From T225 x Lincoln		
T226	chlorophyll deficient	Found in 'Lincoln' in 1943 at Ames, Iowa	IV	WGNBr SYBf
T227	chlorophyll deficient	Found in 'Illini' in 1943 at Kanawha, Iowa	III	WGNBr SYBf
T229	y_{14}	Found in F_4 Richland x Linman 533 in 1943 at Ames, Iowa	IV	PTNBr DYBl
T230	y_{13}	Found in Mandell x Mandarin (Ottawa) in 1944 at Kanawha, Iowa. A43K-643-1	III	PGNBr SYY
T231	chlorophyll deficient	Found in Richland x Linman 533 in 1943 at Ames. AX3015-55. A49-8414	IV	PTNBr DYBl
T232	chlorophyll deficient	Found in 'Hawkeye' in 1950 at Ames, Iowa	III	PGNBr DYIb
T233	y_{12}	Found in 'Hawkeye' in 1950 at Ames, Iowa. N2100	III	PGNBr DYIb
T234	y_{15}	Found in L46-2132 ('Clark' progenitor) in 1952 at Ames, Iowa	IV	PTNBr SYBl

Strain*	Genes or description**	Source***	Maturity	Code††
T235	wm	Found in 'Harosoy' in 1957. L58-274	II	MGNBr DYY
T236	Red-buff seed (Lf_1 ln y_6)	From T143 x "$y_6$ln pc dt w". L46-232	II	W-CTn IRbfRbf
T238	black saddle on seed	Found in X-rayed 'Clark' in 1956 at Columbia, Missouri. S57-3416	IV	PTNBr DYBl
T239	k_2	Found in 'Harosoy' in 1961. L63-365	II	PGNBr DYTn
T240	Ps	Pure line of PI 91.160	III	WLtSpTn DYBr
T241H	st_2	Found in S54-1714 about 1956 at Columbia	IV	WTNBr SYBl
T242H	st_3	Found in AX54-118-2-8 (Blackhawk x Harosoy) at Lafayette, Indiana	II	PGNBr DYG
T243	df_2	Found in colchicine-treated 'Lincoln' at Ames	IV	WTNBr SYBl
T244	df_3	Found in neutron-irradiated 'Adams' at Ames	III	WGNTn SYBf
T245	e_2 Lf_1 dt_1 Ti^2	Pure line of PI 86.024	III	WTNBr DG-GnBl
T247	pale purple flower	Pure line of PI 81.763	II	LpTATn SBlBl
T248	f	Pure line of PI 83.945-4	IV	WTNBr DYBl
T249H	whitish yellow lethal (P_1)	Found in F_3 Clark-pc x Clark-P_1 in 1964. L67-4408A	IV	PTNBr DYBl
T250H	lethal seedling	Found in F_2 Harosoy^5 x Clark-Np in 1964. L67-4439	III	PGNBr DYY
T251H	stunted plant	Found in F_2 Harosoy^5 x T139 in 1961. L67-4440A	II	PGNB SYY
T252	chlorophyll deficient	Found in F_3 Harosoy^6 x T139 in 1963. L64-2612	II	PGNBr DYY
T253	chlorophyll deficient (k_2)	Found in T239 in 1963. L67-4415A	III	PGNBr DYTn
T254	chlorophyll deficient	Found in F_3 Clark^6 x T176 in 1964. L67-4412A	IV	PTNBr DYBl

Strain*	Genes or description**	Source***	Maturity	Code††
T255	lf_2	Found in 'Hawkeye' in 1966 at Ames, Iowa	II	PGNBr DYIb
T256	df_4	Found in 'Hark' in 1966 at Ames, Iowa	IV	PGNBr DYY
T257H	y_{16}	Found in C1128^8 x Mukden at Lafayette, Indiana	III	WGNTn SYBf
T258H	st_4	Found in 'Hark' in 1968 at Ames, Iowa. A72-1103-6	II	PGNBr DYY
T259H	ms_2	Found in F_3 of SL11 (Wayne-r Rpm Rps) x L66L-177 [Wayne x (Hawkeye x Lee)] in 1971 at Eldorado, Illinois. L71L-06-4	III	WTNTn DYBr+Y
T260H	ms_1	Found in a farmer's field in 1966 in North Carolina. N69-2774	VII	WGN- SYBf
T261	k_2	Mutant found in 'Ottawa Mandarin' before 1956 at Columbia, Missouri. S56-26	I	PGNBr SYTn
T262	"double pod"	Found in SRF200 (Hark-ln) about 1971 at Soybean Research Foundation, Mason City, Illinois.	IV	PGNBr DYY

Table 2*

List of varieties with traits of genetic interest

Variety	Former T number	Genes or description	Maturity	Code**
Black Eyebrow	T19	i^k	II	WTNBr SBrBl
Blackhawk		e_3 ep Eu Rps	I	WGNBr SYBf
Carlin	T195	gray seed coat	IV	PTNBr SGG
Chief	T119	Np	IV	PGNBr SYIb
Clark		$Dt_1 dt_2 e_1 E_2$ $l_1 L_2$ $Rcs_1 rcs_2$ rj_3 Ti^1	IV	PTNBr DYBl
Columbia	T38	$d_1 d_2 G$ $Fg_1 fg_2 fg_3$	III	PGNDBr SGnBf
Corsoy		eu	II	PGNBr DYY
CNS		rxp	VII	PTNTn -YBr
Dunfield	T9	$l_1 l_2$ Rj_4	III	WGNTn SYBf
Ebony		dt_1	IV	PLtNBr SBlBl
Flambeau		rpg_1	00	PTNBr SYBl
Gibson		rcs_1	IV	WGNTn DYLbf
Grant	T237	td	0	WLtNBr SYBl
Hardee		Rj_2 Rj_3	VIII	WGNTn -YBf
Harosoy 63		E_3 Ep im Rpg_1	II	PGNBr DYY
Illini	T10	Dt_1 Fe Rps	III	WGNBr SYBf
Jackson		ncl	VII	WGNBr -YBf
Kanrich		Rpm	III	PGNBr DYY
Kent		Rcs_2	IV	PTNBr DYBl
Kingwa	T206	ab Pb td	IV	PGNBr SBlBl
Kura		G k y_3	III	WTNBr SGnBl
Laredo	T246	$W_3 w_4$	VI	LpTNBl -BlBl

Variety	Former T number	Genes or description	Maturity	Code**
Lee		Ncl rj_4	VI	PTNTn SYBl
Lincoln		np Rcs_1 rps	III	WTNBr SYBl
Manchu		Dt_1 i^i	III	PTNBr SYBl
Mandarin		I	I	PGNBr SYY
Medium Green	T44	cyt-G	I	PGNBr SGnBf
Merit		Im	0	WGNBr DYBf
Minsoy		fr	0	PTNTn SYBr
Mukden		Rps_1 fg_1 Fg_2 Fg_3	II	WGNBr SYBf
Norchief		Rpg_1	0	PTNBr SYBl
Ogemaw	T27	r o	00	WTNBr SRbrRbr
Peking	T6	$rhg_1 rhg_2 rhg_3 Rhg_4 i$	IV	WTNBr SBlBl
Seneca	T188	$L_1 L_2$	II	WGNBl SYBf
Sooty	T4	$B_1 B_2 B_3$(G T td)	IV	PGNTn BBlBl
Soysota	T25	i n r O	I	PTNBr SBrBr

*For additional information see section VI, "Genetic Stocks Available," Soybean Genetics Newsletters Volumes 1 and 2, and ASA Monograph No. 16, Chapter 4, "Qualitative Genetics," by R. L. Bernard and M. G. Weiss. American Society of Agronomy, Madison, Wisconsin.

**Descriptive code sequence: 1234 567 (underlined letters used in code).

1 — Flower Color: Purple, White, Magenta, or Light purple.
2 — Pubescence Color: Tawny, Light tawny, or Gray.
3 — Pubescence Type: Normal, Sparse, Appressed, Curly, Glabrous, Irregular, Puberulent, or Semi-appressed (Sa Sp means that pubescence is both semi-appressed and sparse).
4 — Pod Color: Black, Brown, or Tan.
5 — Seed Coat Luster: Dull, Shiny, Intermediate, or Bloom.
6 — Seed Coat Color: Yellow, Green, Gray, Black, Brown, Reddish brown, Imperfect black, or Buff (may have prefix Light or Dark).
7 — Hilum Color: Same abbreviations as seed coat color.

Table 3*

Tetraploid Soybeans

Cultivar	Source
Blackhawk	**
Chippewa	**
Chippewa (non-nodulating)	**
Clark	Dr. H. H. Hadley, Univ. of Illinois, Urbana
Dunfield	T214 colchicine treated, 1943
Dunn	(unknown)
Gibson	Dr. H. H. Hadley, Univ. of Illinois, Urbana
Harosoy	**
Harosoy 63	(unknown)
Hawkeye	**
Lincoln	T212 colchicine treated
Manchukota	**
Mandarin (Ottawa)	**
Richland	T213 colchicine treated

*Plants and/or seeds were characterized for the following traits: flower color, pubescence color, pod color, seed coat luster, seed coat color, hilum color, and peroxidase (Ep or ep).

**Colchicine treated Ames, Iowa, April 1958.

Table 4*

Primary trisomics

Trisomic	Origin	
A	T241(st_2st_2)	A72-147-19
B	T241(st_2st_2)	A72-147-36
C	T258(st_4st_4)	A72-114-5

*A complete description of these three primary trisomics can be found in "Chromosome Transmission and Morphology of Three Primary Trisomics in Soybeans (*Glycine max*)" by R. G. Palmer. 1976. Canadian Journal of Genetics and Cytology (accepted for publication).

Table 5*

Crosses of _Glycine gracilis_ x _G. max_

Plant introduction		Cultivars		
PI	x	Clark e_2	Clark 63	Hark
65.388		+		
79.593			+	
79.648		+	+	+
79.694		+		
79.727		+	+	
80.488-1			+	
81.763		+	+	+
81.765			+	
81.766			+	
81.767			+	
81.768				+
81.770			+	+
81.771			+	+
81.772		+		+
81.773			+	
81.785			+	
82.532			+	+
86.002			+	+
86.046			+	
135.589		+		
135.590		+		
153.292		+	+	+
189.866				+
189.950			+	+
189.951			+	+
232.987			+	+
232.988			+	+
232.989			+	+
232.990			+	+
232.991				+
232.992			+	+
291.274A		+		+
291.274B				+
291.275		+	+	
291.276		+	+	+
291.277		+		
291.278		+		
291.309C			+	+

*We have been crossing Plant Introductions that are listed as _Glycine gracilis_ with cultivars of _G. max_. F_2 seeds are available from most of the combinations. Please send requests to R. G. Palmer, USDA, Agronomy Department, Iowa State University, Ames, IA 50011.

VII. RECENT SOYBEAN GENETICS AND BREEDING PUBLICATIONS

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